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TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1933

No. 611

ELECTRIC CABLE JOINT COMPANY, PETITIONER,

vs.

BROOKLYN EDISON COMPANY, INC.

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SECOND CIRCUIT.

PETITION FOR CERTIORARI FILED NOVEMBER 28, 1933.

CERTIORARI GRANTED JANUARY 8, 1934.

SUPREME COURT OF THE UNITED STATES

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IN UNITED STATES CIRCUIT COURT OF APPEALS, SECOND CIRCUIT

In Equity. No. 5474

ELECTRIC CABLE JOINT COMPANY, Plaintiff-appellant,

vs.

BROOKLYN EDISON COMPANY, INC., Defendant-appellee

STATEMENT UNDER RULE 13, PARAGRAPH 4, OF THE RULES OF THE UNITED STATES CIRCUIT COURT OF APPEALS

1. Bill of Complaint filed April 23, 1931, for infringement of Letters Patent of the United States No. 1,172,322.

2. The names of the parties are as follows:

Electric Cable Joint Company, a corporation duly organized and existing under the laws of the State of Ohio, plaintiff-appellant, and

Brooklyn Edison Company, Inc., a corporation duly organized and existing under the laws of the State of New York, defendant-appellee.

3. The several dates when the respective pleadings were filed and the pages where they appear in the record are as follows:

April 23, 1931—Bill of Complaint, p. 1.
June 2, 1931—Answer, p. 9.
[fol. c] March 19, 1932—Plaintiff's Interrogatories, p. 490.
March 26, 1932—Defendant's Answers to Plaintiff's Interrogatories, p. 495.

5. The case was tried on final hearing by Judge Robert A. Inch, April 18th, 19th, 21st and 22nd, 1932.

6. No question was referred to as commissioner, commissioners, master or referee.

7. October 5, 1932, Final Decree entered dismissing the Bill of Complaint with costs.

8. Defendant's Findings of Fact and Conclusions of Law.

9. Plaintiff's Objections to Defendant's Proposed Findings of Fact and Conclusions of Law.

10. October 24, 1932, Appeal perfected and petition for appeal allowed by Judge Robert A. Inch.

[fol. 1] IN UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK

In Equity. No. 5474

ELECTRIC CABLE JOINT COMPANY, Plaintiff

vs.

BROOKLYN EDISON COMPANY, INC., Defendant

BILL OF COMPLAINT

To the Honorable the Judges of the District Court of the United States, Eastern District of New York:

The plaintiff, Electric Cable Joint Company, a corporation of the State of Ohio, having its principal office in the City of Cleveland, State of Ohio, brings this Bill of Complaint against the defendant, Brooklyn Edison Company, a corporation of the State of New York and a resident of Borough of Brooklyn, in the Eastern District of New York, where it has a regular and established place of business and where the infringement hereinafter complained of has been and is being committed, as well as elsewhere. And thereupon plaintiff says:

I. On information and belief on March 13, 1915, Philip Torchio was the first, sole, true and original inventor of certain new and useful improvements in "Protective [fol. 2] Devices for Electric Cable Joints", not known or used by others before his invention or discovery thereof, and not patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to his application for Letters Patent of the United States therefor, and not in public use or on sale in this country for more than two years prior to said application, and not patented in any country foreign to the United States on an application filed by himself or his

legal representatives or assigns more than twelve months prior to the filing of his application for Letters Patent in this country, and that said invention had not and has not been abandoned to the public.

II. That on the 13th day of March, 1915, said Philip Torchio duly made and filed an application in writing with the Commissioner of Patents of the United States for Letters Patent for said invention and improvements in accordance with the then existing Acts of Congress.

III. On the 22d day of February, 1916, after due compliance with the requirements and conditions of the statutes of the United States in such case made and provided and then in force, Letters Patent of the United States No. 1,172,322 were issued on said application to said Philip Torchio, his heirs and assigns for his and their sole use and benefit.

IV. Plaintiff herein is the owner of the entire right, title and interest in and to the aforesaid Letters Patent and of all claims, demands and causes of action in law or in equity [fol. 3] arising out of past or future infringement of said Letters Patent and of the sole and exclusive right to make, use and sell the invention and improvements set forth in said Letters Patent throughout the United States and the territories thereof.

V. The invention described and claimed in said Letters Patent is of great value and plaintiff has spent large sums of money upon the development and perfection of the same for the purpose of rendering it of great utility to the public; in consequence of which said invention has gone largely into use throughout the United States.

VI. Said Letters Patent were held valid and infringed in an opinion rendered December 6, 1929, by the United States Circuit Court of Appeals for the Sixth Circuit in the case of Metropolitan Device Corporation vs. The Cleveland Electric Illuminating Company, published in 36 Fed. (2d) 477. A Decree for damages and an injunction was entered accordingly in the District Court for the Northern District of Ohio, Eastern Division on the 12th day of September, 1930, of which a copy is attached.

VII. Defendant, well knowing the premises, but with intent to injure plaintiff, to interfere with its business and to

deprive it of the profits derived and to be derived from making, using and selling said invention has within the Southern District of New York, Eastern Division and elsewhere subsequently to the grant of said Letters Patent and within six years next preceding the filing of this complaint without [fol. 4] the license or consent of plaintiff or its predecessors in interest made, used and sold and caused to be made, used and sold apparatus embodying the invention described and claimed in said Letters Patent, thereby infringing the exclusive rights of plaintiff and receiving large gains and profits therefrom. And defendant is preparing and threatening to continue its infringement of said Letters Patent and thus to inflict further injury, damage and loss upon the plaintiff. But to what extent defendant has profited by reason of the aforesaid infringement, plaintiff is ignorant, and, therefore, prays an accounting.

VIII. Plaintiff or its predecessor in title has caused all apparatus made and sold by it and embodying the aforesaid invention to be marked "patented" together with the day and year of the patent involved as notice to the public of plaintiff's rights under said patent, and this defendant has been in other ways notified and fully advised of plaintiff's said patent rights.

IX. Plaintiff fears and has reason to fear that unless defendant be restrained by a writ of injunction issuing out of this Court, it will continue its aforesaid infringement and will deprive plaintiff further of the gains, profits and advantages which would otherwise accrue to it.

Wherefore, plaintiff prays—

(a) That defendant be compelled by a Decree of this Court to account for and pay over to plaintiff all such gains and profits and the value of such advantages as have accrued to it by reason of the infringements herein complained of, and also such damages as plaintiff has sustained [fol. 5] by reason of said infringements; and that because of the wilful nature of said infringements the damage be increased threefold and the defendant be compelled to deliver to plaintiff all apparatus or parts of apparatus containing or made in accordance with said patented invention and in the possession of said defendant.

(b) That the case be referred to a Master to determine and report to the Court the extent of such gains, profits, advantages and damages.

(c) That defendant, its agents and employees be perpetually enjoined and restrained by a writ of injunction issuing out of and under the seal of this Court from directly or indirectly making, using or selling or causing to be made, used or sold any apparatus embodying the invention of said Letters Patent and that a preliminary injunction be issued to the same effect pending the trial of this cause, and

(d) That defendant be decreed to pay the cost of this suit and that plaintiff have such other and further relief as the equities of the case may require.

To the end, therefore, that defendant may, if it can, show cause why plaintiff should not have the relief hereby prayed and full, true, direct and perfect answer make, but not under oath, answer under oath being hereby expressly waived, according to the best of its knowledge, information and belief, to the several matters hereinbefore averred, as fully and particularly as if the same were here repeated and the defendant specially interrogated as to each, may it please your Honors to grant unto plaintiff a writ of subpœna ad [fol. 6] respondendum, issuing out of and under the seal of this Honorable Court directed to said defendant commanding it to appear and make answer to this Bill of Complaint and to perform and abide by such order and decree herein as to the Court may seem just.

Electric Cable Joint Company, by Thomas E. Lipscomb, President. Usina & Rauber, Solicitors for Plaintiff, 71 Broadway, New York City.

Duly sworn to by Thomas E. Lipscomb. Jurat omitted in printing.

[fol. 7] Copy

IN UNITED STATES DISTRICT COURT FOR THE NORTHERN DISTRICT OF OHIO, EASTERN DIVISION

In Equity. No. 1772

METROPOLITAN DEVICE CORPORATION, Plaintiff

vs.

CLEVELAND ELECTRIC ILLUMINATING COMPANY, Defendant

FINAL DECREE

This cause came on for hearing upon the application of the plaintiff for entry of a decree according to the mandate of the Circuit Court of Appeals heretofore entered in this case, and was submitted to the Court. On consideration whereof, it is ordered, adjudged and decreed:

1. That Letters Patent of the United States, No. 1,172,322, issued to P. Torchio, February 22nd, 1916, for Protective Device for Electric Cable Joints, and assigned to plaintiff, Metropolitan Device Corporation, are good and valid in law.

[fol. 8] 2. That said P. Torchio was the first true and original inventor of the device and improvement described and claimed in said Letters Patent.

3. That plaintiff, Metropolitan Device Corporation is the lawful owner of said Letters Patent.

4. That the defendant, the Cleveland Electric Illuminating Company, has infringed upon said Letters Patent, and particularly claims 3 and 4 thereof, and upon the exclusive right of the plaintiff under the same.

5. That a perpetual injunction issue out of and under the seal of this Court directed to said defendant, the Cleveland Electric Illuminating Company, its associates, directors, officers, attorneys, clerks, agents, servants and workmen enjoining and restraining them and each of them during the remainder of the term of said patent from directly or indirectly making or causing to be made, using or causing to be used or vending to others to be used in any manner any articles, device of apparatus containing, embodying or em-

ploying the said invention and improvements granted by the said Letters Patent and particularly claimed in said third and fourth claims thereof, and from infringing upon or violating the said Letters Patent in any way whatsoever, provided, however, that in view of the fact that the infringing devices now in actual use by defendant on its lines cannot be immediately discontinued without damage and interruption of public service, defendant within thirty (30) days from the date of entry of this decree shall commence [fol. 9] the removal and discontinuance of use of the infringing devices now in actual use on its lines and shall complete said removal and discontinuance of use by the 15th day of February, 1931.

That defendant do recover of the plaintiff its costs and disbursements in this Court to be taxed and that plaintiff recover of the defendant its costs in the Circuit Court of Appeals.

Jones, Judge

IN UNITED STATES DISTRICT COURT

[Title omitted]

ANSWER

To the Honorable the Judges of the District Court of the United States for the Eastern District of New York:

Defendant, Brooklyn Edison Company, Inc., for answer to the bill of complaint, or to so much thereof as it is ad- [fol. 10] vised it is necessary to answer, says:

1. Defendant is not advised save by the bill of complaint, whether plaintiff, Electric Cable Joint Company, is a corporation duly organized and existing under the laws of the State of Ohio, and therefore calls upon plaintiff for strict proof thereof.

2. On information and belief, defendant denies the allegations and each of them, contained in paragraphs of the bill of complaint marked "I", "IV", "V", "VIII" and "IX".

3. On information and belief, defendant denies the allegations and each of them, contained in paragraph of the

bill of complaint marked "II", except that on or about March 13, 1915, Philip Torchio made and filed an application in writing with the Commissioner of Patents of the United States for letters patent for an alleged invention and improvements in said application described.

4. On information and belief, defendant denies the allegations and each of them contained in paragraph of the bill of complaint marked "III", except that on or about February 22, 1916, letters patent of the United States No. 1,172,322 were issued to Philip Torchio.

5. Upon information and belief, defendant denies the allegations and each of them, contained in paragraph of the bill of complaint marked "VI", except that said letters patent, in respect to claims 3 and 4 therein contained, were [fol. 11] held valid and infringed in the opinion in said paragraph mentioned, and excepting further that defendant is not advised save by said paragraph of the bill of complaint, whether a decree for damages and an injunction was entered as in said paragraph of the bill of complaint alleged, and therefore calls upon plaintiff for strict proof thereof so far as the same may be material herein; but defendant alleges that it was not a party to said action or in any way concerned in the prosecution or defense thereof.

6. Defendant denies the allegations and each of them, contained in paragraph of the bill of complaint marked "VII", and further denies that it has committed any acts of infringement in the Eastern District of New York or in any other place or places within the United States of America.

7. Defendant, further answering the bill of complaint, on information and belief, alleges that the aforesaid Philip Torchio was not the original or first inventor or discoverer of the alleged invention mentioned in the bill of complaint, or of any material or substantial part thereof, and defendant further alleges that each and every substantial and material part of said alleged invention was shown and described in various United States and foreign letters patent, as follows:

United States Patent No. 534, 802 H. Lemp, February 26 1895;

British Patent No. 11,280, 1894, W. Geipel, June 11, 1894;
British Patent No. 12,146, 1909, C. Vernier, May 22, 1909;
British Patent No. 11,932, 1887, C. D. Abel, Sept. 2, 1887;
British Patent No. 29,756, 1913, J. F. Watson, Dec. 24, 1913;

[fol. 12] and divers other United States and foreign letters patent at present unknown to defendant, but which when ascertained if prays leave to add to this answer by amendment.

8. Defendant, further answering the bill of complaint, alleges that the alleged invention mentioned in the bill of complaint, and each and every material and substantial part thereof, had been, prior to the date of the alleged invention or discovery thereof by Philip Torchio, described and published in printed publications among which defendant cites the following:

(a). Treatise, article or dissertation entitled "De berekening, de bouw en het bedrijf van het Kabelnet der Gemeente Amsterdam", by Gerard De Geäer, submitted June 20, 1907, to obtain the degree of Doctor in the Technical Science at the Technical University at Delft; printed by F. J. Belinfante, formerly A. D. Schinkel, The Hague, 1907.

(b). The paper or article by C. Vernier, entitled "The Laying and Maintenance of Transmission Cables", received January 25, 1911, and read before the British Institution of Electrical Engineers March 9, 1911, with the discussion, published under dates of March 9, 1911, March 6, 1911, and April 11, 1911, in the Journal of the (British) Institution of Electrical Engineers, originally The Society of Telegraph Engineers; edited by P. F. Rowell, Sec'y., volume 47, 1911, pp. 313-389, and printed by L. & F. N. Spon, Ltd., 57 Haymarket, London S. W., and Spon & [fol. 13] Chamberlain, 123 Liberty Street, New York, 1911.

(c). Article entitled "The laying and maintenance of transmission cables", by C. Vernier, published in "The Electrician" (London), issue of March 10, 1911, pp. 854-856, printed and published by George Tucker, at the Editorial Printing and Publishing Offices of "The Electrician", Salisbury Court, Fleet Street, London, England, 1911.

(d). Article entitled "The laying and maintenance of transmission cables", by C. Vernier, A. M. I. E. E., published in "The Electrical Review" (London), issue of March 24, 1911, pp. 492-494, printed and published by H. Alabaster, Gatehouse & Co., at 4 Ludgate Hill, E. C. 4, London, England, 1911.

(e). Article entitled "Vacuum method of filling cable joints", published in "The Electrician" (London), issue of March 24, 1911, pp. 962-963, printed and published by George Tucker, at the Editorial Printing and Publishing Offices of "The Electrician", Salisbury Court, Fleet Street, London, England, 1911.

(f). The patent and specifications therein contained in British patent No. 11,048, 1891, issued to Walter Claude Johnson and Samuel Edward Phillips, for Improvements in the preparation and laying of electrical mains on the Brooks' System, published by the British Patent Office in [folk 14] and subsequent to March and April, 1892.

(g). The report of the Electrical Commission appointed to consider the location, arrangement and operation of electric wires in the District of Columbia, being Ex. Doc. No. 15, House of Representatives, 52d Congress, 1st Session, printed by the Government Printing Office, Washington, 1892.

Also the British patents set up under paragraph 7, above. (See Monroe & Byrne letter June 15/31.)

and in divers other printed publications in the United States and elsewhere at present unknown to defendant, but which when ascertained it prays leave to add to this answer by amendment.

9. Defendant, further answering the bill of complaint, alleges that the alleged invention mentioned in the bill of complaint, and each and every material and substantial part thereof, was known to others in this country prior to the alleged invention of the aforesaid Philip Torchio, and that each and every material and substantial part of said alleged invention was in public use in this country before the alleged invention of said Torchio, and for more than two years prior to the date of filing of the aforesaid application, and among such prior uses of the alleged invention defendant cites the following:

(a) The Edison Electric Illuminating Company of Boston, in connection with 25,000 volt cable installed by British Insulated & Helsby Cables, Ltd. in and subsequent to July, 1914, as a part of a transmission system in Boston, Mass., or from Boston to Dedham, Mass., via Norwood and Wal- [fol. 15] pole, Mass.

(b) Consolidated Gas, Electric Light & Power Company of Baltimore, in connection with 13,000 volt cables in and subsequent to June, 1911, in Baltimore, Md.

10. Defendant, further answering the bill of complaint, alleges that in view of the prior art as it existed at the time of the alleged invention, said patent No. 1,172,322, mentioned and described in the bill of complaint, is null and void and lacking invention, and required only mechanical skill, or the expected skill and judgment of those skilled in the art, to produce the alleged invention.

11. Defendant, further answering the bill of complaint, alleges, that said patent No. 1,172,322 mentioned and described in the bill of complaint was and is inoperative or invalid by reason of the patentee claiming as his invention or discovery more than he had a right to claim as new, and such invalidity has not been cured by a reissue of said patent.

12. Defendant, further answering the bill of complaint, upon information and belief, alleges that it is at once apparent upon an inspection of the patent, No. 1,172,322, mentioned and described in the bill of complaint, that the patentee has claimed more than that of which he was the original or first inventor or discoverer; that the patentee or his immediate assignee became aware that more was claimed in and by said patent than the patentee had in fact [fol. 16] invented or discovered, when said letters patent were issued or soon thereafter, and that said patentee and his assigns unreasonably neglected or delayed to enter a disclaimer of such parts of the process, improvement or device patented as was in obvious excess of the part, if any, of which he was the true inventor, until February 11, 1927, when Thomas E. Murray, then alleged owner of said patent, made disclaimer of the entire improvement described in the letters patent mentioned in the bill of complaint except as in said disclaimer stated, in consequence

of which unreasonable neglect and delay the whole and every part of said patent became and remains wholly void.

13. Defendant, further answering the bill of complaint, alleges, that the disclaimer filed in the Patent Office February 14, 1927, by Thomas E. Murray, then alleged owner of said patent No. 1,172,322, mentioned and described in the bill of complaint, renders the claims, and each of them, contained and set forth in said patent so ambiguous, indefinite and uncertain that they fail particularly to point out or distinctly to claim the part, improvement, or combination which is claimed as the invention or discovery of the inventor.

14. Defendant, further answering the bill of complaint, alleges that said patent No. 1,172,322, mentioned and described in the bill of complaint, as it now exists, due to material changes by the disclaimer filed in the Patent Office February 14, 1927, as aforesaid, is not for the same invention as that for which the application of said Philip Tor- [fol. 17] chio filed March 13, 1915, was made, and is not for the same invention as that for which the aforesaid letters patent were granted.

15. Defendant, further answering the bill of complaint, on information and belief, alleges that plaintiff's assignors and predecessors in title to the patent No. 1,172,322 mentioned and described in the bill of complaint, did not at any time from February, 1916, to April, 1931, make, use or sell the electric cable joint described in said patent, and did not issue to others licenses to make, use or sell such electric cable joints upon payment of a stipulated royalty, and did not formally license buyers of materials and supplies for said joint sold by them to use the alleged invention for which said patent was granted, but plaintiff's said assignors and predecessors in title in said period sold only a limited quantity of the unpatented materials and supplies used or employed in and for the construction of said electric cable joint, and endeavored and attempted to exact as the condition of the right to make and use said electric cable joint that said unpatented materials and supplies should be purchased only from them, in unlawful extension of the monopoly granted by said patent to said unpatented materials and supplies, and in abuse of the limited rights granted by said patent, in consequence of which

plaintiff's assignors and predecessors in title had no right to maintain this action, and plaintiff may not maintain the same.

16. Defendant, further answering said bill of complaint, alleges that prior to the service of said bill of complaint upon it, defendant was at no time and in no way notified, [fol. 18] informed or advised by plaintiff or by any of plaintiff's predecessors in title, or by anyone acting for plaintiff or for plaintiff's said predecessors in title, that the electric cable joints or any part thereof, made, used or employed by defendant, or any of defendant's acts, were in infringement of the letters patent No. 1,172,322 mentioned and described in said bill of complaint.

17. Defendant, further answering the bill of complaint, alleges that it is, and at all times since prior to 1920, has been, a public service electric corporation, duly organized and existing under the Transportation Corporations Law of the State of New York, and that it has all of the rights granted, and is subject to all of the duties imposed, by the Transportation Corporations Law and the Public Service Commission Law of the State of New York; that defendant supplies, and since prior to 1920 has supplied, electricity in and throughout the Borough of Brooklyn, City and State of New York, for public and private use and for lighting public streets and places and public and private buildings therein; that the electric cable joints and insulating compound, liquid, fluid or material contained therein, now and for the past six years used by the defendant, were developed by defendant by original experimentation and research conducted and carried on by defendant; that said electric cable joints are necessarily made by defendant on the ground or in manholes to connect and join sections or reels of lead sheathed electric cable, which can be purchased by defendant from the manufacturers thereof only in [fol. 19] lengths of not exceeding approximately 250 feet to 600 feet each; which sections or reels of cable must be connected or joined by defendant to construct useful high tension electric line conductors of the lengths required by defendant for its uses and purposes, that; in the construction of the electric cable joints used by it, defendant has endeavored to make the joints as closely as practicable like the cable itself and to insulate said joints with an insulat-

ing fluid, liquid or compound as closely as practicable like the insulating fluid, liquid or compound contained in the cable, although in its more recent practice defendant has made an extensive use of transformer oil so as to permit the use of one kind of oil for transformers, cable terminals and cable joints; that defendant cannot discontinue the use of the aforesaid electric cable joints and of said insulating fluid, liquid or material without great expense to it, and without great prejudice to the public service in which it is engaged.

18. Defendant, further answering the bill of complaint, alleges that Thomas E. Murray, and/or Metropolitan Device Corporation, were the owners of the alleged patent No. 1,172,322, mentioned and described in the bill of complaint, from June 10, 1922, to November 1, 1930; that said Thomas E. Murray, who was also an officer, director and principal stockholder of, and who managed and controlled, said Metropolitan Device Corporation, was a Director, and a member of the Executive Committee of the Board of Directors, of defendant prior to June 27, 1922, and was also a Director, and a member of the Executive Committee of the Board of Directors, of defendant from February [fol. 20] 24, 1925, to November 27, 1928, and was employed by defendant, and acted for defendant, as a consulting engineer between June 27, 1922, and February 24, 1925; that in his capacity as Director and consulting engineer of and for defendant, and otherwise, said Thomas E. Murray knew of defendant's electric cable joint practice, and was fully conversant therewith, and with each and every material and substantial part of all of the electric cable joints installed and used by defendant prior to the resignation of said Murray as Director of defendant on or about November 27, 1928, and as such Director and/or consulting engineer said Thomas E. Murray participated in the selection, installation, use and maintenance of the electric cable joints and of the insulating fluid, liquid or material contained therein, so installed and used by defendant; that said Thomas E. Murray, and/or Metropolitan Device Corporation at no time, and in no way, informed, advised or notified defendant that the electric cable joints intsalled and used by it, or the insulating fluid, liquid or material therein contained, infringed upon any patent, including said letters patent No. 1,172,322, held or owned by him, or

by Metropolitan Device Corporation, but on the contrary said Metropolitan Device Corporation informed defendant that the patented feature distinguishing the high tension electric cable joint owned or controlled by it was a copper gauze stocking, a device at no time used or employed by defendant; nor did said Murray or said Metropolitan Device Corporation at any time, or in any way, ask or demand that defendant pay any compensation, royalty or license fee for the use of the electric cable joints installed and used [fol. 21] by defendant, or for or on account of the insulating fluid, liquid or material placed or used therein by defendant. From all of which acts and conduct of said Murray and of said Metropolitan Device Corporation defendant was led to infer and believe, and did infer and believe, that the electric cable joints so installed and used, and the insulating fluid, liquid or material placed and used therein by defendant, were not an infringement upon any patent held or owned by said Murray, or by Metropolitan Device Corporation, or, if and so far as the electric cable joints, or the insulating fluid, liquid or material used or employed therein by defendant, embraced or included the whole or any material or substantial part of any such patent, that said Murray and said Metropolitan Device Corporation consented to the employment and use thereof by defendant without the payment of any compensation, royalty or license fee by it, and acting and relying upon the conduct of said Murray and of said Metropolitan Device Corporation, as aforesaid, and such inference and belief, defendant installed, used and maintained the electric cable joints, and the insulating fluid, liquid or material, heretofore used and employed and which are now used and employed by defendant, in consequence of all of which said Murray and said Metropolitan Device Corporation were and are and plaintiff is estopped from maintaining this action. And defendant also pleads the conduct aforesaid of said Thomas E. Murray and Metropolitan Device Corporation as constituting a license and consent, binding upon each of them and their successor in title, the plaintiff, that defendant [fol. 22] should have and enjoy and continue to have and enjoy the right to use and employ the alleged invention of said letters patent in its high tension electric lines.

19. Defendant, further answering the bill of complaint, on information and belief, alleges that from June 10, 1922,

to November 1, 1930, the title to said patent No. 1,172,322 mentioned and described in the bill of complaint, asserted and relied upon herein by plaintiff, was vested in Thomas E. Murray, and/or Metropolitan Device Corporation; that during said period of about nine years plaintiff's said predecessors in title knew of their own rights, if any, in and under said patent, and knew and were familiar with defendant's electric cable joint practice, and with each and every material and essential part of the electric cable joints and the insulating fluid, liquid or compound contained therein, used by defendant in and throughout said period; that plaintiff's said predecessors in title during all of said period had ample opportunity to establish their rights, if any, against defendant, but stood by and took no action or steps to that end; that during said period defendant, with the knowledge of, and without objection from, plaintiff's said predecessors in title, expended large sums of money in the construction of the electric cable joints used by it and in and for the electric cable, conductors and other equipment in connection with which said cable joints were installed and used, and that by reason of the inaction and laches of plaintiff's said predecessors in title for and during the period aforesaid, defendant was led to believe that plaintiff's said predecessors in title pos- [fol. 23] sessed no patent in any way infringed by defendant's said electric cable joint or any part thereof, or that any patent claimed or possessed by them was worthless, or had been abandoned by them, in consequence of which laches plaintiff may not maintain this action.

Wherefore, defendant prays that the bill of complaint be dismissed with costs to defendant, and for such other and further relief as to the Court may seem just.

Brooklyn Edison Company, Inc., by John D. Monroe, Its Solicitor. Monroe & Byrne, Attorneys and Solicitors for Defendant, Brooklyn Edison Company, Inc., 50 Broadway, Borough of Manhattan, City of New York.

New York, June 1, 1931.

[fol. 24] IN UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK

ELECTRIC CABLE JOINT COMPANY, Plaintiff,

vs.

BROOKLYN EDISON COMPANY, INC., Defendant

Narrative Statement of the Evidence

Before Hon. Robert A. Inch, U. S. D. J.

Brooklyn, N. Y., April 18, 1932.

APPEARANCES:

Usina & Rauber, Esqs., Solicitors for Plaintiff, by D. A. Usina, Esq., of Counsel.

Monroe & Byrne, Esqs., Solicitors for Defendant, by Charles Neave, Esq., and John D. Monroe, Esq., of Counsel.

STATEMENT OF CASE

Mr. Usina: This, if your Honor please, is a patent case, a rather simple one, on a single patent and a single claim of that patent.

I hand you a copy of the patent so that you will know what we are talking about.

[fol. 25] I will say at the outset that the case is being defended by three distinct parties, although the suit is brought against the Brooklyn Edison Company. It appears from interrogatories and answers that they are joined by the General Electric Company and the General Cable Company in the defense of the suit.

The patent which your Honor has shows that the device is entitled a protective device for electric cable joints. As a matter of fact, it is a joint, it is a complete joint itself, according to the claims.

Now, electric cables of the type to which this invention is directed are of a peculiar sort. There are half a dozen, or perhaps a hundred, different kinds of electric cables, but this is directed to the electric cable that is commonly used in the streets in Brooklyn, a rather large city; in fact, you

have sometimes one and sometimes three cables proper, conductors, as they call them, which are in a sort of row of copper wires that are carefully insulated and separated from each other, and they are bound together, and a lead sheath is extruded closely around the whole thing, so that in cross section they look like this (handing to the Court).

The Court: Come right up.

Mr. Usina: You will see there the three separate cables, each one surrounded by insulation, by insulation of paper tape wound tightly around it and impregnated with oil. You can see that the thing is still oily, and it will remain oily no matter how long we have it.

Around each of these is a little wire strip which you will see of copper—not wire, but a tape of copper, and the [fol. 26] amount triangularly spaced between the three cables. There is a packing of jute which is also impregnated with an insulating oil, and then around the whole is this closely compressed lead sheath.

Now, those cables are laid in ducts underground, and the corners, the cable ends, are joined to another cable. It is these joints that will always give a great deal of difficulty when you come to high tension cables. These cables carry a very high voltage of electricity. It seems easy enough to connect them to copper parts, which they do usually use, a copper sleeve surrounding tightly those ends so as to carry the current through, but the difficulty is to connect the insulation so as to get that joint as well insulated as the body of the cable, 10 or 20 or 100 feet away from the joint.

Numerous schemes have been proposed for wrapping the joint with tape of various sorts and filling the joint, casing with fillers of various sorts, designed primarily to keep out water and air and dust and things of that sort.

If you will look at the patent, at Fig. 1, you will see at the two ends 7 the ordinary lead sheath cable. The lead sheath is cut off, and between the two ends of the lead sheath is an outside casing which has an insulation 8 on the lower side. It is inside in that casing that all the mechanism of this invention is included. That casing is soldered to the lead sheath by a lot of solder indicated at 9 at each end, which is a wipe, a good plumber's wipe joint, indicating a tight connection there.

The part 8 which surrounds the joint is called the [fol. 27] sleeve, whereas the part 7 which surrounds the wrapper outside is called a lead sheath.

Now, it is between the blank spaces in the middle of that joint marked 5, and they set up there any one of a dozen different methods of wrapping the ends of the cable with insulating material similar in a general way to that which is used in wrapping cables in the lead sheath.

Surrounding all that, this inventor Torchio put a wire netting marked 13, which, however, has nothing to do with the present issue, but that was one of the features of this invention. That was supposed to take care of certain stray electric currents.

Outside of that, there is a body of oil which you will see indicated in the usual way to indicate a liquid, entirely surrounding it, and above the oil is a reservoir 10, which is also filled with oil; so that you have a large quantity of oil in there.

Now, the wrappings around the ends of the cables are permeable. That is, they are of paper, or generally of paper. They are sometimes varnished cambric.

There are also various other things which were in themselves, by reason of the material of the wrapping around the cable ends, permeable to the oil, and the oil runs clear through them and insulates them just as oily as the cable itself, and there is a supply of oil in the reservoir 10 for a purpose which I will state further on.

Commonly, before this patent was taken out, this lead sheath, this casing 8, was filled with what they called a filling compound or a joint compound, which was intended to [fol. 28] be not so hard as to crack when it gets cold, not so soft as to flow out after it flowed into the pipe and way into the cable and leaving the joint dry, which was the very thing they wanted to prevent; so they had a sort of putty which they said was the best possible thing for filling that joint. They would heat certain material and pour it in, something to pervent voids. They would heat the joint and they would melt materials and pour them in and let them harden. There were various types of joints used.

Now, this inventor found that with all possible filling compounds there was the usual danger of voids, air spaces within the joint itself. It also happened that the cable filled with voids, outside of the joint and very near to it. He, for

the first time, realized that that was due to a peculiar quality of these electric cables which he called breathing.

When a current runs through a cable, especially a high voltage cable, it has become heated. Naturally, that tended to expand, and now being in this lead sheath, there is expansion of the copper and lead cable that squeezes this oily wrapping that is around the cables and squeezing the oil out of it, towards the end where there is a void, and to escape into the joint; and then when the current is shut off or is diminished the cable gets colder and shrinks, and tends to leave little voids in the cable at various points along its length, particularly at the end.

If there is any void, any air space the size of a pin-point, in that insulation surrounding the cable, they have a little arc in there, a little spark, which, in the course of time, [fol. 29] chars the paper around it and makes a little bigger hole and a bigger hole, or a bigger spark, and finally destroys the efficiency of the cable, and they have to take it out.

Now, you see, this void then causes voids in the cable, and this man for the first time had an idea of supplying oil to the void of such a character that it could flow down into the cable in such a quantity that it would constantly keep the cable full of oil and prevent the occurrence of these air spaces; and the use of it has been attended, as the evidence will show, with remarkable results.

We are building up old cables which would not stand more than 13,000 volts to the point where they will stand 27,000 volts and rejuvenating old cables, taking old cables in the City of Brooklyn which were practically useless when they increased the voltage, and making them useful, so that they did not have to take them out of the ground and replace them with new and better cable.

It has been a wonderful invention, although in stating it it is a very simple thing. It consists briefly in taking this type of oil for this type of cable and filling it with oil of such consistency and in such quantity so as to supply the demands made by the cable.

Now, I have said that there is a certain brass sleeve around it, which you are to disregard. That is covered in some of the claims, and I am going to submit the one claim on which we rely, which is Claim 4.

That calls for an electric cable, comprising a sheath, a line conductor, that is a copper conductor having a joint; [fol. 30] that is joined inside of the joint casing by a copper sleeve, as I have stated, a body of pervious insulating material enclosing said joint, that is the wrapping of the joint with cambric or other material around the joint, a wrapping of pervious insulating material enclosing the joint, the said sheath—that is, the lead sheath of the cable—being removed for a distance sufficient to expose said pervious body; that is to say, all within that lead casing there, the lead sheath of the cable itself has been removed, and a sleeve of impervious material of greater diameter than said body, that is the outside sleeve or shell in which the joint is enclosed; that, of course, is of greater diameter than the body of the rack, enclosing the same, and hermetically united at its ends to said cable sheath. That is soldered with a plumber's joint. A receptacle communicating with the interior of said sleeve. That is the receptacle just above the sleeve. And an insulating fluid adapted to permeate said pervious body. That is the pervious body which wraps around the ends of the cable, contained in said receptacle, that is to say, the insulating oil is contained in said receptacle, and the space between said body and said sleeve. That insulating fluid fills the little reservoir above, and fills also the entire sleeve, or at least, the space within the sleeve around the pervious wrappings on the conductors.

The Court: Well, Mr. Usina——

Mr. Usina: Yes.

The Court: Do I understand then that in a sense the inventor discovered the making of a sort of reservoir of this oil?

Mr. Usina: Yes, sir.

[fol. 31] The Court: Which would permeate as needed——

Mr. Usina: Yes.

The Court (continuing): —and keep the——

Mr. Usina: Yes.

The Court (continuing): —rest of the cable in such a condition that these stops would not arise?

Mr. Usina: That is right.

The Court: Yes.

Mr. Usina: Yes, he was the first to discover that.

The Court: There is nothing in any special oil, or anything of that kind?

Mr. Usina: Only that the consisteney of the oil must be thin.

The Court: That the consisteney of the oil must be thin?

Mr. Usina: None of the oils that they used before were used on account of the fact they would not flow. It must be an oil that will flow.

The Court: The discovery was, as you claim, of an oil of a certain consisteney in a reservoir?

Mr. Usina: Yes.

The Court: That can be used in this manner, is that right?

Mr. Usina: Yes, that is right.

The Court: In other words, it is the permanence of this reservoir always ready to function

Mr. Usina: Yes.

The Court (continuing): that was the difficulty overcome by this inventor, is that right?

Mr. Usina: Yes, roughly stated that is quite right, your Honor, but he discovered the principle beyond that that [fol. 32] you could take care of the injury done to a cable by its breathing.

The Court: Yes.

Mr. Usina: Nobody had found that out or pointed that out.

The Court: The breathing was, you might say, the mother of the invention; it was the necessity.

Mr. Usina: The breathing was the necessity, yes, exactly so. He found it so.

The Court: All right.

Mr. Usina: Previously people had opposed the use of a thin oil here because they said it would run down into the cable and leave the joint dry; and this man said, "We propose to use a thin oil to advantage, and it will be thin enough, and the quantity great enough to supply the demand."

The Court: All right.

Mr. Usina: Now, when we came in to try a previous suit, which I will refer to in this case as the Cleveland suit, we found lots of cases in the old art of iron pipes and other kinds of pipes in the ground with wires running loosely in them, and pipes filled with oil, in order to make the claim that our invention did; our patent did not attempt to cover such remote things. We put a disclaimer in restricting it

to this particular type of cable and to a joint adapted to it.

The Court: Yes.

Mr. Usina: In which we say in the disclaimer, which is attached thereto, "hereby makes disclaimer of the improvement described except for electric cables which comprise a line conductor, insulating wrapping permeated with insulating compound and a sheath of flexible inelastic metal [fol. 33] constituting a unitary product of manufacture and commerce which is portable and capable of being drawn through conduits."

That is described as an ordinary lead sheath cable, as distinguished from the old, in which the wire or the lead sheath was in the ground and the wire was pulled through it loosely. This is a different thing.

"And except as to the insulating liquid which is fluid at ordinary working temperatures"—these things are still at atmosphere when they are working. We wanted it very broad at that working temperature. —"of such cables and in quantity sufficient to supply at all times the demands made by the cable in use, and by the joint."

The Court: I see. All right.

Mr. Usina: Now, patent Claims 3 and 4 were the basis of a suit against the Cleveland Electric Illuminating Company, which is the distributor of electric current in Cleveland, just as the Brooklyn Edison Company is here.

After being determined invalid for various reasons the Court held both claims valid and infringed, and that matter has been settled.

We have not thought it necessary to rely upon Claim 3 here. The distinction between the two of them is that Claim 3 provides that you must have this oil and have it in sufficient quantity; and Claim 4 is more specific and refers exactly to a reservoir in addition to the ordinary joint casing. I believe the combination occurs with the supplementary reservoir. I thought it sufficient to limit the case to one claim.

Now, I do not know whether your Honor wants me to [fol. 34] go ahead or wants to hear from the other side.

The Court: Just what they prefer. Do you care to speak now?

Mr. Neave: I would be very glad to, your Honor. I would like to look at the patent just a little bit more, to

see, more definitely than Mr. Usina has done, what the patentee says his invention is.

On page 1, line 13:

"The invention consists in the construction whereby the joint is immersed in a fluid insulating medium adapted to permeate the pervious wrapping of the joint, whereby said fluid after permeation of said wrapping is retained therein by a denser body of insulating material surrounding said wrapping".

That is, in the first part of this sentence, Mr. Torchio states that the oil he is going to use, or the fluid insulating medium, as he calls it, is adapted to permeate a pervious wrapping at the joint; that is, when they make a joint they scape all the insulation off the various conductors in the joint, and then they connect each pair of conductors, end to end, and then they put a wrapping around the joint.

The patent says that should be a pervious wrapping; that is, it is to soak up oil, and the statement here is that the function of the insulation is to permeate the pervious wrapping there.

In the first place, the defendant does not use a pervious wrapped joint. It uses impervious wrapping of the joint. [fol. 35] The last part of the same sentence is:

"Whereby said fluid after permeation of said wrapping is retained therein by a denser body of insulating material surrounding said wrapping."

The idea there, as the patent explains later, is that this pervious wrapping soaks up the oil, and then the whole joint box is filled with a denser medium. That the defendant is not doing.

Then line 20 proceeds:

"and whereby the joint is inclosed in two metallic sleeves united at their ends to one another, separated between said ends and electrically connected at said ends to the cable sheath, whereby the potential on the said sleeves becomes that of the sheath and breaking down of insulation between said sleeves or ionization of air between them is prevented."

Those two metallic sleeves are the outer metallic sleeve in which the joint is cased and the inner gauze thing. That

the defendant is not using. So the defendant does not do anything specified in this statement of invention here.

Now, let us skip down to page 1, line 88, where, after expressing what he conceived to be, but what we will show was not, the condition of the prior art, that is, the use of heavy insulating materials like pitch or paraffin instead of a fluid, he says:

"I have succeeded in overcoming the foregoing difficulty by the following means:

[fol. 36] In Fig. 1, I show the usual lead covering sleeve 8, provided on its upper side with a reservoir 10 closed by a screw plug 11. I fill the sleeve and reservoir with any suitable insulating oil or other liquid which is fluid at low temperature and preferably of a character which will combine with the material used in the body of the cable for permeating or embedding the insulating wrappings."

The joint wrappings are here referred to, indicating now that all he thought his oil was to permeate was the wrappings in the joint and not to go into the cable.

The Court: And if I may interrupt you, in the device used by the defendant you claim this oil would not permeate because you do not use a wrapping that would allow it.

Mr. Neave: That is right. Does not permeate the wrappings in the joint.

"This liquid I preferably force into the sleeve 8 under pressure sufficient to drive it into the interstices of the cable ends and into the joint wrappings and fillings. When the introduction of the liquid is complete, I permit it to fill the reservoir 10, which is finally closed. The oil in the reservoir then serves to supply any deficiency in the sleeve caused by absorption and breathing of the cable or the disturbance of the conductors carrying sudden overload currents, so that the joint insulation is not only thoroughly permeated at the outset, but continues submerged in a bath of insulating oil."

[fol. 37] There is something else I want to read on page 2, but I would like first to come to the line 50 which bears upon the portion I have already read. Up to this point we have got the oil going in the pervious wrapping in the joint.

The Court: Yes.

Mr. Neave: Line 50, page 2:

"It is to be observed that the insulating fluid not only permeates the wrappings and fillings at the joint, but also percolates into the insulation of the cable ends exposed in order to make the joint. This is of practical importance, because it often happens that during the making of the joint, the exposure of said ends permits of the permeating liquid used in the original manufacture of the cable to 'bleed' or run out." That is, when the cable is cut oil will ooze out. " and a consequent failure of insulation at these points ensues. This I have found to be the cause of breakdowns which were apparently unaccountable. The new fluid put into the joint sleeve supplies this loss and effectually prevents the difficulty."

That is, the oil is to permeate the permeable wrappings of the joint, and as far as the cable is concerned, it is to make up for the oil that has run out of the cable at its ends when it was cut. That is as far as it goes.

Now, let us see about the reservoir. The first paragraph on the top of page 2 reads:

"Instead of making the reservoir 10 in the form of a separate chamber communicating with the sleeve, as shown [fol. 38] in Fig. 1, I may dispose the sleeve eccentrically on the joint, so that the greatest clearance will be uppermost, as shown at 12 in Fig. 6."

You have that before you.

The Court: Yes.

Mr. Neave: Except it is a little bit left up in the air. "as shown at 12 in Fig. 6. In this way, I produce an additional holding space for the oil within the sleeve itself."

That is, when he speaks of the reservoir, he does not necessarily mean something connected by a pipe to the sleeve, but the sleeve itself may be the reservoir.

Then at line 9, on page 2, is a paragraph which speaks in detail of something that I spoke of when I first began reading the specification; that is, the idea of Torchio that he will let the oil penetrate into the pervious wrappings at the joint, and having gotten in those wrappings, he will fill the whole thing full of heavier oil. That we do not do.

The next paragraph, beginning at line 23 on page 2, relates to the use of this gauze wire installed between the outer sheath and the cable joint, and that we do not use. That is something that is emphasized in the patent, and has been emphasized by the owners of this patent, as we will show you in a moment.

Now, with reference to Claims 3 and 4 having been sustained by the Court of Appeals for the Sixth Circuit, as Mr. Usina said, that, of course, is true.

I obtained the impression, however, from what he said, that the Court of Appeals for the Sixth Circuit had sus- [fol. 39] tained this claim because it had found some invention in the reservoir. That would be an erroneous impression, because there was no discussion there of any invention residing in a reservoir, either the enlarged casing or the separate reservoir. That did not figure in it at all. Claim 4 sort of ran with Claim 3. Claim 3 is for what the Court found to constitute the essence of invention; and in order that you may see what our position here is on the question of invalidity of the patent I have already spoken of non-infringement but on the point of invalidity I would like to read to you on what basis the Court of Appeals for the Sixth Circuit stated that this patent was a valid patent for we shall show you here in the proof of prior use and prior publication which were not in the record in the Sixth Circuit, complete answers to the findings of the Court of Appeals of the Sixth Circuit upon which it based its conclusion of validity. That decision of the Court of Appeals of the Sixth Circuit is in 36 Fed. (2d) 477. After discussing the question of the disclaimer, the Court comes to the question of invention (p. 479), and says this:

"As to invention: The necessity therefor was great. In high voltage cables, i. e., cables carrying in excess of 15,000 volts, the dielectric loss—" that is the loss by leakage because of poor insulation—"the dielectric loss from faulty insulation, with the resultant destruction of the wrappings of the cable and the breaking down of the joints, was serious. Torchio discovered that this loss was due in part to [fol. 40] the 'bleeding' of the insulating compound from the exposed cable ends during installation."

That bleeding, that same bleeding is in a prior publication, which teaches that the oil must fill up the spaces due to

that bleeding. That was not before the Court of Appeals for the Sixth Circuit.

"He also discovered that the cable 'breathed' or 'sucked', that is, that while in use the heat expanded it and that if correspondingly contracted while cooling, that this bleeding and expansion of the cable forced the insulating compound from the interstices of the pervious insulating wrappings and fillings, permitting dielectric loss and structural damage. The problem was to restore this lost insulation. The teaching had been that the insulating compound in the joint should not be soft enough to flow."

That is really the gist of the whole thing. As Mr. Usina told you this morning, what the Court of Appeals for the Sixth Circuit found was that the gist of this invention was using a filling compound in the joint which was soft enough to flow; and we have a complete disclosure of that prior to Torchio, which was not before the Court of Appeals for the Sixth Circuit. The Court then says:

"The thought was that the compound should not be permitted to escape and leave the joint unprotected."

[fol. 41] Of course, it should not. That was the thought, and it is the thought. Torchio has not changed that. Torchio does not say, "Let the insulating compound get out of the joint and leave the joint unprotected". Nobody has thought that.

"Torchio substituted a liquid insulating compound for the compound with a low melting point therefore in use in the cable sleeve."

I think that must be a misprint, that "low". The idea expressed is that Torchio substituted a liquid insulating compound in place of a solid in these joints. We shall show you that is precisely what had been disclosed before Torchio.

"Torchio's liquid compound would and did, especially under pressure, flow along the cable length between the conductors and the leaden sheath and refill the empty cells of the previous insulation."

We shall prove to you that is precisely what was done prior to Torchio's invention; and this was not before the Sixth Court of Appeals.

"This was new and useful and was a commercial success. It was not a mere refinement of the former method; it was a reversal of it."

We shall prove to you that there was no reversal. Torchio does just what had already been disclosed. But that proof was not before the Circuit Court of Appeals for the Sixth Circuit.

[fol. 42] Now, of course, the plaintiff would like to confine this discussion to Claim 4, and it is the only one in suit by his election, although at first they notified us that they relied upon Claims 3 and 4.

They think they have another element in here, a reservoir, and that they have more chance of winning. I am not content as to that. I want to get to the gist of this invention. What is the substance of it? I read to you what the Court of Appeals for the Sixth Circuit stated to be the substance of the invention and it did not depend on having a reservoir. The substance of what was found to be the invention was in claim 3 (which did not include a reservoir) and claim 4 also was sustained because it also included the subject matter of claim 3. But there was no discussion as to whether the reservoir added anything of patentability.

We shall show you that the Court of Appeals was wrong in finding that Torchio made any invention not necessarily wrong on the basis of the record upon which it decided that case, but wrong on the facts as they will now appear. Upon these facts, the patent is invalid.

Mr. Usina: May I only reply a movement to one of the points that Mr. Neave has made as to Claim 3?

I cannot understand why this defendant wants to try Claim 3 except when I realize that the General Electric and the General Cable Company are also interested.

They may be interested in defeating the broader claim, but this Brooklyn Edison Company, which is the nominal defendant, so far as I am concerned, does not use anything [fol. 43] except that which comes within Claim 4, and therefore would have no interest in any other claims.

Mr. Neave: May I answer that?

The Court: Yes.

Mr. Neave: Do not let me give you a wrong impression. If I gave you that, I am sorry. I do not insist that plaintiff rely on Claim 3. The plaintiff has a perfect right to rely only upon the claim he chooses, but I do insist that the substantive invention as found by the Court of Appeals for the Sixth Circuit should not be overlooked; and that was the thing covered by Claim 3.

The Court: There was no rehearing in the suit?

Mr. Neave: No.

Mr. Usina: I do not know whether or not there was a petition for a rehearing.

Mr. Neave: I was not in that case. It was some years ago.

Mr. Usina: There was a petition for a rehearing but it was denied.

On the ground of notice I have just had some information this morning. I have not had time to get proof of it; but I thought that Mr. Whittemore might be willing to stipulate that the President of the plaintiff company, Mr. Alexander, had submitted to him a proposal on behalf of the utility and cable companies, which were going to hold a meeting in St. Louis, and I will ask if you will stipulate that in February, 1931, we had a conference with Mr. Alexander and a proposal from Mr. Alexander for a settlement of his claims against all of the utility and cable companies. [fol. 44] Mr. Neave: Mr. Whittemore, of course, can answer that question himself. Mr. Whittemore does not represent the defendant in this case, so there is no notice.

Mr. Whittemore: I am not in a position to make a stipulation inasmuch as I am not an attorney in the case, but I will be very glad to look over my records in view of what Mr. Usina has said, and report to Mr. Neave.

Mr. Usina: Instead of reporting to Mr. Neave, will you look over your records, and then appear as a witness for me on that point?

Mr. Neave: It will not be necessary. He will do whatever is necessary on that.

Mr. Usina: Mr. Whittemore has told me now what he is willing to stipulate, and if I may interrupt the proceeding to do that I will be very glad to do so.

Statement by Mr. Manvel Whittemore. "On or about February 18, 1931, Mr. E. R. Alexander, who had been previously introduced to me by D. A. Usina, Esq., as representing the then owners of the Torchio patent No. 1,172,322, made to me, as patent counsel for General Cable Corporation, an offer substantially as set forth on page 437 of the Electrical World of March 7, 1931, reading as follows:

"'The third event was the offer on February 18, 1931, by a representative of the patent assignee to consider settlement on the basis of joints to be installed in the future and to waive past infringements if the proposed plan is accepted. The settlement would be based on supplying a per- [fol. 45] centage of the joints of their number, and it could be extended over a period of years, possibly two years beyond the expiration of the patent, which will occur on February 22, 1933. The offer points out that the patentee would disregard the royalty rate established in the alleged settlement with the Cleveland Company by a prior assignee. If utilities were licensed to apply the patent they would not have to pay an additional royalty if they purchased joints from cable manufacturers.'

"I do not and did not at that time represent the Brooklyn Edison Company, nor did I at any time communicate this offer to the Brooklyn Edison Company."

OFFERS IN EVIDENCE

It is stipulated that this statement by Mr. Whittemore may be introduced into evidence on behalf of the plaintiff.

Supplementing that, I ask leave to introduce the copy of the Electrical World in question, in order to make the context clear. I will substitute for it, by leave of the Court, a photostat of the cover and of the page in question, page 437, being the Electrical World of March 7, 1931.

The Court: No objection to that, Mr. Neave?

Mr. Neave: No objection.

(Marked Plaintiff's Exhibit 26 in evidence.)

Mr. Usina: I would like to offer a certified copy of the patent in suit.

(Marked Plaintiff's Exhibit No. 1 in evidence.)

Mr. Usina: A certified copy of the File Wrapper and contents of the application for the patent in suit, so as to identify certain patents which you cited there.

[fol. 46] Mr. Neave: If your Honor please, to that offer of the File Wrapper, if it is limited for the purpose of showing what happened before the Patent Office, I have no objection, but I object to anything in the File Wrapper being offered as proof of anything stated therein.

Mr. Usina: That is all I want.

The Court: That is all he wanted.

(Marked Plaintiff's Exhibit 2 in evidence.)

Mr. Usina: A certified copy of the disclaimer.

(Marked Plaintiff's Exhibit 3 in evidence.)

Mr. Usina: Certain publications which were offered in the Cleveland case, I want to offer here, to show the actual state of the art as distinguished from the state of the art which might have been shown by the case selecting the patent and publications of the defendant, simply to enlarge the showing of the state of the art.

I will first offer a book called "Technical Sessions of the Board or Committee of Underground Construction", published by the National Electric Light Association, and read before its meeting on May 29, 1911.

I submit the complete volume to counsel, and will offer in evidence the title, or a photostat of the title page and the pages 9 and 11.

(Marked Plaintiff's Exhibit 4 in evidence.)

Mr. Usina: The same on a publication entitled "Transactions of the American Institute of Electrical Engineers", January to December, 1917, Volume XXXVI. I submit the complete volume to counsel, and offer in evidence the title page, photostat of the title page and of page 428.

Mr. Neave: I object to that as not bearing upon the patent in suit. It is later than the patent in suit.

[fol. 47] The Court: I will take it. Overrule the objection and give you an exception.

(Marked Plaintiff's Exhibit 5 in evidence.)

Mr. Usina: If we may stop a minute, this shows that even after Torchio got the patent they still thought the old

compound was the right thing, and it took some years to teach the industry the value of the invention.

I want to offer also copies of several patents which were cited in the Cleveland case, because I think they add to what the defendant is going to offer, and will give the Court a better view of the complete state of the art prior to Torchio's invention.

(Discussion off the record.)

Mr. Usina: These are the following patents cited by the Patent Office.

Mr. Neave: I was going to suggest that the stenographer just copy that in.

Mr. Usina: We had better put it off and offer those in our Cleveland suit. We shall not refer to those much during the trial, your Honor, but in our brief we may want to refer to them.

The Court: Yes.

Mr. Usina: Patterson, 277,335 of 1883. That will be Exhibit 6.

(Marked Plaintiff's Exhibit 6 in evidence.)

Mr. Usina: Wesslau, 416,143, of 1889.

(Marked Plaintiff's Exhibit 6-A in evidence.)

Mr. Usina: Wiley, 433,922, of 1890.

(Marked Plaintiff's Exhibit 6-B in evidence.)

Mr. Usina: Purcell, 488,027, of 1892.

(Marked Plaintiff's Exhibit 6-C in evidence.)

Mr. Usina: Rosati, 706,599, of 1902.

(Marked Plaintiff's Exhibit 6-D in evidence.)

[fol. 48] Mr. Usina: Viele, 888,674, of 1908.

(Marked Plaintiff's Exhibit 6-E in evidence.)

Mr. Usina: Egerton, 1,073,596, of 1913.

(Marked Plaintiff's Exhibit 6-F in evidence.)

Mr. Usina: Now, the patents offered in the Cleveland suit. Mark those separately, please.

Brooks, 165,535, of 1875.

(Marked Plaintiff's Exhibit 7 in evidence.)

Mr. Usina: Hunt, British patent, 4824 of 1877.

(Marked Plaintiff's Exhibit 7-A in evidence.)

Mr. Usina: Brooks, 210,986, of 1878.

(Marked Plaintiff's Exhibit 7-B in evidence.)

Mr. Usina: Jacques, 227,168, of 1880.

(Marked Plaintiff's Exhibit 7-C in evidence.)

Mr. Usina: Abel British patent, 11,932, of 1887.

(Marked Plaintiff's Exhibit 7-D in evidence.)

Mr. Usina: Thea, the De Ferranti British patent, 16,237, of 1889.

(Marked Plaintiff's Exhibit 7-E in evidence.)

Mr. Usina: Wesslau, 415,751, of 1889.

(Marked Plaintiff's Exhibit 7-F in evidence.)

Mr. Usina: Whipple, 1,083,170.

(Marked Plaintiff's Exhibit 7-G in evidence.)

Mr. Usina: Watson British patent 29,756, of 1913.

(Marked Plaintiff's Exhibit 7-H in evidence.)

Mr. Usina: I will put those copies in, but he has the marks on them. Subject to correction later.

The Price British patent 8,842, of 1914, which was cited by the plaintiff in the Cleveland case.

(Marked Plaintiff's Exhibit 7-I in evidence.)

Mr. Usina: Being that we have some printed copies made [fol. 49] of the Circuit Court of Appeals' decision, I will offer one of those as our next exhibit.

(Marked Plaintiff's Exhibit 8 in evidence.)

Mr. Usina: Certified copy of the decree in the Cleveland case.

(Marked Plaintiff's Exhibit 9 in evidence.)

Mr. Usina: I would like to offer as a physical exhibit the entire record in the Cleveland case, so that your Honor may know the facts upon which the opinion was arrived at in that case. I do not think it is necessary to copy it entirely into this record.

The Court: In case of an appeal you do not want to have to print all that record?

Mr. Usina: No, but I thought if I offered it in as a physical exhibit we would not have to reprint it, but simply have it here for your Honor's reference if you wanted to refer to it.

Mr. Neave: I object to it being in evidence in this case, your Honor. He has already put in evidence the various prior patents and publications except two, which I will put in.

The Court: I do not think it is necessary to put it in evidence. However, I have always the privilege of looking at the record.

Mr. Usina: Then, may I simply leave the copy with you if you wish to look at it?

The Court: Exactly. I have a right to do that.

Mr. Usina: I will offer our title papers as the decree proves that the title at the time was in the Metropolitan Device Corporation; and I offer here an assignment from the Metropolitan Device Corporation to one Perfler, November 1, 1930.

Mr. Neave: Your Honor, I object to this. The decree that is entered in another case to which we were not a party, [fol. 50] has nothing to do with this. It is nothing against us.

(Marked Plaintiff's Exhibit 10 in evidence.)

The Court: I was looking at these Claims 3 and 4. They are identical, with the exception that in 4, which is the one relied upon here——

Mr. Usina: Yes.

The Court (Continuing): —there is the additional name of the element, the receptacle.

Mr. Usina: That is right, yes, sir.

The Court: Consequently, in a sense, especially in view of Mr. Neave's statement, I will have to consider the entire Claim 4, which will take in all of these other elements of the invention.

Mr. Neave: Yes, your Honor.

The Court: I do not want to encumber the record unnecessarily. The decree, of course, in the Sixth Circuit Court of Appeals, decided certain things for all the world.

Mr. Usina: Yes.

The Court: It is not binding upon the defendant as a conclusive judgment, but it certainly can be referred to.

Mr. Neave: Yes.

The Court: Now, we have the decree in evidence, and I have the record of the trial.

Mr. Usina: Yes.

The Court: Which I can, for convenience, instead of sending out there and getting it from the library of the Circuit Court of Appeals for the Sixth Circuit——

Mr. Usina: Yes.

The Court: What more do you want, Mr. Usina?

Mr. Usina: I do not want any more than that except I want to prove the title in the present plaintiff, which is not [fol. 51] the same plaintiff that owned the patent at the time of the Cleveland suit.

The Court: I am not concerned with who won out there particularly, so long as it is not this defendant.

Mr. Usina: I want to prove our title here. I think it is sufficient to prove that at the time of the decree in that suit——

The Court: That is what I am going to do.

The Court: I thought it had something to do with what you proved out there.

Mr. Usina: I only started with the proposition that out there I proved the title up in the Metropolitan Device Corporation.

The Court: Yes.

Mr. Usina: And I am going to bring certain assignments since that time to prove title in the present plaintiff.

The Court: Oh, well, that is all right.

Mr. Neave: I object to that. As I understand it, in the Sixth Circuit Court of Appeals title was not proved but was stipulated. Here they are suing us on the patent issued to Torchio, and I want to know that this plaintiff is the owner of it, and how did it get from Torchio to them. So they ought to have the complete chain of title from Torchio to the present plaintiff.

Mr. Usina: I shall be glad to do it.

Mr. Neave: I do not know why they should start from a stipulated title.

The Court: It is quite important that the plaintiff be the one that owns the patent.

Mr. Neave: Yes.

Mr. Usina: Yes, of course.

[fol. 52] The Court: Consequently, I will allow you to prove it in your own way but I think Mr. Neave is correct that a stipulation out there for the purpose of that appeal or trial is not sufficient here.

Mr. Usina: I was simply trying to keep the record down.

The Court: All right.

Mr. Usina: I have given you an assignment from the Metropolitan to Perfler, and now I have an assignment from Perfler to the Electric Cable Joint Company, April 18, 1931, which is the present plaintiff.

(Marked Plaintiff's Exhibit 11 in evidence.)

Mr. Usina: Now, in order to satisfy Mr. Neave's request for the chain of title up to the Metropolitan Device Corporation—I have not the originals here——

Mr. Neave: You can substitute them.

Mr. Usina: I can send and get them, but I think I have some certified copies.

I have an assignment from Torchio, the patentee, to Murray, June 10, 1922.

(Marked Plaintiff's Exhibit 12 in evidence.)

Mr. Usina: And an assignment from Murray to the Metropolitan Device Corporation, dated February 11, 1927.

(Marked Plaintiff's Exhibit 13 in evidence.)

Mr. Usina: That completes the chain of title from the inventor to the present owner.

Now the plaintiff filed certain interrogatories which the defendant has answered. I do not know whether they are part of the pleadings or whether they should be offered as an exhibit. Has your Honor any preference in the matter?

The Court: I have not any preference at all.

[fol. 53] Mr. Usina: Then, I will offer them as two exhibits, being Plaintiff's Interrogatories and Defendant's Answers. Mark them as two exhibits, one plaintiff's interrogatories.

(Marked Plaintiff's Exhibit 14 in evidence.)

Mr. Usina: And the other, defendant's answers.

(Marked Plaintiff's Exhibit 15 in evidence.)

(Short recess taken.)

FRANK N. WATERMAN, called as a witness on behalf of the plaintiff, having been duly sworn, testified as follows:

Direct examination.

By Mr. Usina:

My name is Frank N. Waterman; age 66; residence, Summit, New Jersey; consulting engineer.

Mr. Usina: Will you agree that Mr. Waterman is qualified to testify as an expert in this case?

Mr. Neave: I will certainly agree that he knows a lot about electrical matters. How much he knows about cable joints, I do not know, but you need not give his qualifications so far as I am concerned. If I am interested in asking him about cable joints, I will cross examine him.

The Court: All right.

The Witness: I will take the patent in suit Torchio, No. [fol. 54] 1,172,322, and explain to the Court the structure therein, with particular reference to the subject matter of Claim 4, and in the light of the disclaimer. The Torchio patent is addressed particularly to the construction and protection of joints for power cables carrying high voltages. By power cables I mean cables for the distribution of electrical energy for lighting and power purposes as distinguished from telephone and telegraph cables, and others carrying low voltage currents where insulation does not raise a problem.

The reason for the use of these high voltages that are employed nowadays to a large extent in power cables is the necessity for distributing economically. The low voltages that we employ in our houses and buildings for the lighting of lamps and the operation of motors would not permit of the economic distribution of current because of the large losses that are involved.

Therefore, the voltages employed have progressively grown larger, because the element causing losses is the flow of current through the resistance of the conductors. The higher the voltage the lower the current can be for a given amount of power to be distributed, and the voltage, therefore, has been progressively raised. The losses for a given amount of power, in fact, vary in a general way inversely as the square of the voltage, so that if we can multiply the voltage by 10, we could, other things being equal, divide the losses by 100. Therefore, there is a very great advantage in using high voltages, but high voltages bring insulation problems that do not exist with the low voltages, and it is to those insulation problems that the patent in suit is addressed.

[fol. 55] In cities where the amount of power to be distributed is very large indeed, and the difficulties of handling overhead conductors are very great, it is customary, and in many instances a legal requirement, that the conductors should be put under ground, and for this purpose the conductors themselves have to be laid up as cables inside of a protecting sheath; and such cables are ordinarily installed under ground in duct systems, into which they have been drawn and from which they can be withdrawn, those duct systems being connected by manholes at convenient intervals.

Alternating currents are ordinarily employed for the distribution of power on a large scale, because they afford the simplest means of converting from the high pressure at which the power is distributed to the low pressure at which we use them; and in alternating current it is possible, and for many years it has been customary, to employ, what is known as the three-phase system, which requires three conductors. Therefore, the power cable consists ordinarily, or at least very commonly, of a three-conductor cable, or if the amount of power to be distributed is very large, then three individual separate cables, each separately insulated.

In any case, there is the problem of insulating the cable conductor from the earth, and in the case of the three-conductor cable the conductors must be insulated from one another.

The patent in suit, as appears from Fig. 2, illustrates a three-conductor cable, the conductors being shown in cross-

section at 1, 2 and 3. For convenience I produce a drawing A.

[fol. 56] Mr. Usina: Which we offer in evidence as Plaintiff's Exhibit 16.

(Marked Plaintiff's Exhibit 16 in evidence.)

Mr. Usina: Mark it Exhibit 16 and refer to it, please.

The Witness: Exhibit 16 shows the fragmentary cross section of a duct system, the ducts being indicated at D with cables C in the duct. The cable is shown in cross section and consists of three conductors, 1, 2 and 3, each conductor being made up of a large number of smaller wires cabled together. Each conductor has around it numerous layers of insulating material, as indicated at 4, and this is most usually paper which has been impregnated with oil. Sometimes varnished cambric has been used. This is wound up to a thickness which depends upon the voltage primarily, that is the electrical pressure that exists on the conductor with reference to the neighboring conductors, and with reference to the earth. For example, at 15,000 volts the paper insulation might be wound up to a quarter of an inch in thickness, and for twice that voltage, perhaps three eighths of an inch.

In the formation of the cable three such insulated conductors are twisted together, the interstices between them being filled ordinarily with a porous material such as jute, which is tightly pressed into the interstices, and then in one type of cable the whole group is surrounded by additional layers of paper, also oil impregnated, as indicated at 5. The jute is indicated at 4A on Exhibit 16. Then a lead sheath is extruded around the whole cable so formed to furnish an [fol. 57] impervious waterproof covering with one that is flexible and will permit of the cable being handled and bent.

This lead is indicated by the letter C in Exhibit 16. This is one type of cable. There is another type that is quite commonly used also. It is known as a shielded cable, sometimes called a type H cable.

In such a cable the individual conductors, after being impregnated with numerous wrappings such as 4 in Exhibit 16, have wound around them a copper tape, so that while all three conductors may be enclosed in one lead sheath, they are, with reference to the earth's potential, akin to three

separate insulated conductors; and in such case the belt course shown at 5 in Exhibit 16 as the added insulation is not employed. Such cables are standard articles of manufacture, whether they are made one way or the other, of those that I have referred to, and are delivered wound on reels or drums for convenient transportation, so that they may be drawn into ducts.

In the process of manufacture they are filled with an insulating oil commonly referred to as compound, which may be of one nature or another. Different materials are employed, but sufficiently fluid so that it can leak from the cable if the ends are exposed, and therefore after the cable has been thoroughly impregnated, as a final step in the process of manufacture, has its ends sealed, so that as it is delivered it is on a drum with the ends hermetically sealed by soldering over the lead cover.

Necessarily the conductors are large to carry the ade- [fol. 58] quate amount of power required in any distribution system that can afford so expensive an insulation as lead cables and ducts.

The sample on your Honor's desk shows quite large copper conductors. Where the amount of power is so large as to require single conductors they may be much larger than that. They may be of the order of an inch and a half in diameter, for example, and weigh six pounds or more per foot just for the copper. But these cables are nevertheless flexible enough so that they can be wound on drums, and can be drawn into conduits.

I have produced, and I have had made, a few simple drawings illustrating conduit systems, and I refer to drawing B.

Mr. Usinas: Which is offered in evidence and marked Plaintiff's Exhibit 17.

(Marked Plaintiff's Exhibit 17 in evidence.)

The Witness: Exhibit 17 shows a horizontal plan view of a manhole, the walls being shown in section. Fragmentary conduit systems are shown at D on the right and left entering the manhole, and cables are indicated at C. They are led through the ducts of the conduit to the manhole and jointed by joints shown at J within the manhole.

It is customary to provide that they bend in the manner indicated which affords means of taking care of the expansion, because in the use the cables vary a good deal in temperature. They are ordinarily carried on brackets, as indicated at B.

[fol. 59] Mr. Usina: Drawing C is offered in evidence as Plaintiff's Exhibit 18.

(Marked Plaintiff's Exhibit 18 in evidence.)

The Witness: Exhibit 18 shows a vertical section taken through a manhole, looking foward one of the duct systems. The ducts are shown at D, and the cables laying therein are marked C.

Mr. Usina: Drawing D is offered in evidence as Plaintiff's Exhibit 19.

(Marked Plaintiff's Exhibit 19 in evidence.)

The Witness: Exhibit 19 shows a longitudinal section That is a vertical section of the two entering duct systems D at the right and left; the cables passing through with the manhole and manhole cover at the top.

In Exhibit 19 the cables and the joints are held on suitable brackets that are diagrammatically indicated at B to carry the great weight that the cables and the joints necessarily have. These are simply embedded in the concrete walls ordinarily, or carried on supports, as indicated at the right in Exhibit 19.

The Torchio patent refers, beginning at line 51 of page 1, to —

"In the ordinary operation of making the joint "

and the drawings which have been marked Exhibit 16 to 19 show what Torchio calls the ordinary joint representing joints without the addition of the improvements of the patent.

[fol. 60] Then, beginning at line 51, the specification states:

"In the ordinary operation of making the joint, the lead sheath 7 of the cable is cut away for a sufficient distance to expose the conductors and permit application of the wrappings, and afterward a lead sleeve 8 is placed over the joint and connected by wiped solder 9 to the ends of the

lead sheathing, thus hermetically inclosing the joint. Through two holes left in the sleeve is a fluid insulating compound adapted to permeate the interstices in the insulating wrappings and filling of the joint is poured."

In other words, the jointing system, as referred to here, consisted of cutting away the sheathing, and exposing the conductors so that the two ends of the conductors could be jointed together ordinarily by putting on a copper sleeve, slipped over the ends and well soldered; a wrapping is then applied to replace the removed part of the insulation, and the sleeve with its wrapping of insulating material is enclosed in a lead sleeve placed thereover, and this lead sleeve filled with a compound which he then proceeds to refer to. He says at line 63:

"I have found that said fluid compounds do not operate efficiently. In some of them as, for example, paraffin, voids or openings are formed, due to the contraction of the material on cooling and hardening."

He then points out that in others the quick cooling and the hardening of the compounds fail to thoroughly impregnate the insulation, and that these compounds, in order to be sufficiently fluid, must be heated pretty hot so as to cause a deterioration of insulation where the hot fluid first contacts with it, as by a partial charring. [fol. 61]

Of course, such charring would convert the insulating material from a good insulator into a fair conductor.

Then he says, beginning at line 73, that:

"In all of them (in all of these compounds) the insulating compound on hardening will crack under mechanical stresses, especially when the conductors carry heavy overload currents."

That refers to the fact that a conductor carrying a current is surrounded by a magnetic field; and where there are conductors near together, all carrying currents, mechanical forces exist between them, and these forces may be very large where the currents are very large; as, for example, during heavy overload or in the event of a short circuit somewhere on the system, that causes a great flow of current.

One of the first duct systems that I ever saw, I saw just after such a short circuit, and the cables had been thrown from the racks and were scattered around on the floor of the manhole in a very chaotic condition as a result of a pretty heavy short circuit.

It is such forces which, of course, need not be so violent as that just instanced in order to cause damage, that Torchio refers to as tending to crack the compounds.

At line 79, he points out the evil results of such cracks and voids. He says:

[fol. 62] "The consequence is that, by reason of these cracks and voids and the ionization of air in them, a lowering of dielectric strength of the joint insulation takes place, so that electric lines transmitting high tension currents, especially if under ground, have their weakest places at the joints and at the ends of the sheathing 7 where connected to the joint covering sleeve 8."

In order to have any adequate understanding of the difficulties that are involved in high tension insulation, particularly in such structures as these joints, it is necessary to realize that conductors carrying high electrical voltage are surrounded by an electric field.

We are accustomed to thinking of magnetic fields as surrounding a conductor carrying current, but we are not so accustomed to thinking of a dielectric field or an electric field which surrounds a conductor which is subject to high pressure. Such an electric field causes or can make itself evident as lines of stress through all of the dielectric material, solid or fluid or gaseous in the neighborhood; and along these lines of stress the current tends to escape.

The distribution of the stress on the insulation depends very much upon the nature of these insulating materials; and the distribution of the stress, the concentration, depends very much on the shape of all conductors that are in the neighborhood. They are, in general, vastly too complicated for any calculation, but in a few cases like the simple cable itself, a single cable inside a lead sheath, these lines of stress will be radial from the cable out to the [fol. 63] sheath, and the stresses will be distributed in that space between the conductor and the sheath, in accordance with the dielectric properties of the insulating material.

I may say in explanation of that term that materials that are used as insulators, including air or vacuum, are referred to generally as dielectrics, and they have various properties. Some of them are very much better conductors for these lines of stress of the electrostatic field than others, and, therefore, the nature of the materials surrounding a conductor under high voltage, as well as the shape and the distribution, govern the distribution of the stresses.

Air is a material of relatively low dielectric constant. It is called, we take it as unity in the scale of the rating of electrical material, and the patentee points out that by these various causes of cracking voids occur, which are filled with air to such a pressure as all the circumstances of use bring about in the joint that the air is normally at or about atmospheric pressure.

Now, such a void filled with air in the midst of material of higher dielectric constant is heavily stressed, and there arises what is known as ionization, which is referred to at line 80 in the passage just quoted. That, without going into the technical aspect of it, that means that the air which would normally be a fair insulator is converted into a conductor, so that current can escape through such air spaces, and the air in the process of ionization may even be heated sufficiently to cause charring of the insulation, and if there is any moisture in the air the difficulty is aggravated, as the moisture itself is a conductor, and it acts as a sort of [fol. 64] wedge and bores its way, wedges its way through the insulation, so that the existence of voids or empty spaces in the insulation is found to be a matter of serious import to the endurance of the joint or of the cable if such voids occur in the cable.

It appears from these defects that, as Torchio says, the joints were commonly the weakest points in the system and would break down due to ineffective joint insulation when the cables were able to stand up. By "stand up", I mean operated without breaking down.

He says that this also extended not merely to the actual joints but to the sections of the cable adjacent to the joints. This is referred to in the quotation that I last read on line 86.

Then, starting at line 88, he says:

"I have succeeded in overcoming the foregoing difficulty by the following means: In Fig. 1, I show the usual lead covering sleeve 8, provided on its upper side with a reservoir 10 closed by a screw plug 11. I fill the sleeve and reservoir with any suitable insulating oil or other liquid which is fluid at low temperature and preferably of a character which will combine with the material used in the body of the cable for permeating or embedding the insulating wrappings."

The cable, as I have already explained, comes to the user impregnated with an oil.

This passage states that when it is joined—jointed, the sleeve should be—the jointed sleeve which is soldered or wiped to the cable lead sheath should be provided with a [fol. 65] reservoir so that the whole joint and reservoir are filled with a liquid, and this liquid is something that is to be misgible with the liquid used in the cable for reasons that appear. He says:

"This liquid I preferably force into the sleeve 8 under pressure sufficient to drive it into the interstices of the cable ends and into the joint wrappings and fillings."

The difference between a joint wrapping and a joint filling is the same as in the cable between the conductor wrapping and the filling.

In Fig. 2, for example, the conductors are each surrounded by wrappings, and then the interstices are occupied by what he calls fillings. The same may be employed in the joint. He says:

"When the introduction of the liquid is complete, I permit it to fill the reservoir 10, which is finally closed. The oil in the reservoir then serves to supply any deficiency in the sleeve caused by absorption and breathing of the cable or the disturbance of the conductors carrying sudden overload currents, so that the joint insulation is not only thoroughly permeated at the outset, but continues submerged in a bath of insulating oil."

The oils that are originally put into the cable appear to be subject to continuous absorption, that is, no matter how thoroughly impregnated the material may be at the start, there seems to be something in the nature of a continued

absorption. That is what I understand is referred to by absorption.

[fol. 66] Also, there is a formation sometimes called a cheese formation or X formation by which the filling material tends to undergo some sort of molecular change of the compounds, and may even tend to form porosities within the cheese material.

Those are causes which lead to the continued desire of the cable for more filling liquid.

Then he refers to breathing. The so-called breathing, so far as I remember, Torchio first pointed out that phenomena, is a result apparently of the changing temperature. The cable goes through cycles when it tends to exude, and then reabsorb, liquid. The conductors carrying current of course become heated. A conductor carrying current always becomes heated, the heating depending upon the resistance of the conductor, and the current which it carries, being proportionate to the square of the current.

The heat, of course, does not readily escape in the cable, so the conductor will be the hottest, and the insulation immediately surrounding it will have nearly the same temperature, while the lead sheath that is exposed to the walls of the duct and to the air in the duct will have a much lower temperature. It results, therefore, that the inside, the middle of—of the cable—expands the most with heat. The insulating oils used in the cable themselves also expand quite markedly with the temperature, so there is a tendency under the heating of the cable for a considerable pressure to develop that tends to expel the oil.

Also under particularly heavy stresses the conductor may [fol. 67] actually move and thus leave voids either in the cable or in the joint where the conductors are joined, and wherever such a void exists it is important that it should be filled with oil.

Of course, the load on any power distribution system fluctuates with the hour of the day, so that the cable goes through something in the nature of a 24-hour cycle when its temperature rises and then falls; and this regular change, plus changes due to special overloads, constitute the breathing effect to which the patentee refers; and it is the purpose, as he states, of the oil in the reservoir to keep the cable continuously under a certain amount of oil pressure, so that the demands of the cable for oil may be satisfied.

In special cases, the temperatures of cables, in their ordinary operation, will run as high as 170 or 180 degrees Fahrenheit; and normally probably the temperatures are of the order of 150 or 160.

At any rate, they are at such temperatures under normal operation that one could not hold his hand on them. Therefore, the expansion is considerable. Of course, there is also some variation of the duct temperatures, and manhole temperatures, but being buried in the ground that is normally quite small, and the temperatures of the earth around the duct are quite low.

Of course, heat escaping from the cables warms the ducts, but the outside is always at a much lower temperature than the inside; and therefore a differential expansion occurs.

Of course, lead has very little power of recovery, having [fol. 68] once been strained, so that if the internal expansion actually suffices to stretch the lead and enlarge it a little, then that space will continue to exist and the reservoir serves the purpose of also replenishing that.

At the top of page 2 he states that: "Instead of making the reservoir 10 in the form of a separate chamber communicating with the sleeve, as shown in Fig 1"—which is set forth as shown at 10 in Fig. 1, he can enlarge the sleeve as shown at 6 and place it eccentrically so as to bring a reservoir space in the sleeve above the level of the joint.

At page 2, line 9, he refers to a use which is not illustrated and not further described, where he says:

"Where for any reason it is not desirable to keep the sleeve filled with a light fluid, such as oil, I may first cause the wrappings and filling of the joint to be permeated with said light fluid, as already described, and then afterward draw off the surplus liquid and substitute therefor an insulating compound of greater density than said liquid to fill the space between the joint and the sleeve."

There is no further reference to that usage, and as I do not understand that it is referred to in Claim 4, I will not consider it further.

He then passes to the addition of a metal sleeve inside of the lead sleeve. This is referred to at page 2, line 23. He says:

"In order still more effectually to prevent any failure of [fol. 69] dielectric strength at the joint, I prefer to inclose

the joint wrapping 5 in an envelope 13 of wire gauze, which is electrically connected at its ends, *a*, *b* to the cut extremities of the lead sheathing on each side of the joint, so that there is a free conducting path between said sheathing extremities through said envelope."

I have called your Honor's attention to the fact that there exists about a conductor carrying high voltage this electric field. In the cables this can be looked upon as radial with respect to the conductor. When we get into the joint and interrupt the lead sleeve, very complicated conditions of electric stress arise. The lead of the sleeve is very much farther away from the conductors, and the fields, the electric fields, set up by the conductors take very complicated figures, so that a very special problem exists in bringing about a correct distribution of these electric stresses, and Torchio therefore provides a sheath which shall be conducting and which shall bring about a favorable distribution of the electrical stresses with respect to the conductor; and he does that by applying copper gauze, indicated at 13 in Figs. 1 and 2, which, as I said, he connects to the lead sheathing at both ends, and binds in place by a wrapping of cord shown at 14.

This, while pervious enough to allow the passage of the oil, has the effect of producing a favorable distribution of the field, or a more favorable distribution of the field than would have existed had the lead sheath been cut off and left at the point *a*, *b* without any further provision for [fol. 70] properly controlling the distribution of the field.

At page 2, line 50, Torchio again emphasizes the fact that the oil filling which he uses, fluid at ordinary temperatures, does not merely serve for the impregnation of the joint, but also that it percolates into the insulation of the cable and takes care of the various causes of the voids such as I have already considered.

He says that:

"It is to be observed that the insulating fluid not only permeates the wrappings and fillings at the joint, but also percolates into the insulation of the cable ends exposed in order to make the joint. This is of practical importance, because it often happens that during the making of the

joint, the exposure of said ends permits of the permeating liquid used in the original manufacture of the cable to 'bleed' or run out, and a consequent failure of insulation at these points ensues. This I have found to be the cause of breakdowns which were apparently unaccountable. The new fluid put into the joint sleeve supplies this loss and effectually prevents the difficulty."

The joint of the patent as disclosed in the specification, and as I understand, is intended to be referred to in Claim 4, consists of a union of the conductors which were originally contained in the sheathing, formed by cutting away the lead sheath for a sufficient distance to unite the conductors, applying the pervious wrappings.

[fol. 71] I should perhaps have commented on the pervious wrappings.

The wrappings of the cable are joined or laid up in oil or continuously coated with oil while being wound. I do not mean laid up, but immersed in oil. That is a matter of importance for reasons that perhaps are only partly understood.

A single layer of paper will have very high dielectric strength.

You take oiled paper, well impregnated with oil, and it might stand 600 to 900 volts for .001 of an inch of thickness, while if you wind that same paper up until it has, say, one-quarter of an inch of thickness, then each .001 of an inch would be found to stand very much lower pressure, and it might be only 200 or 300 volts, where each layer, if tested alone, would stand six, seven, eight or more hundreds of volts.

It is also a property of insulating oils that they will stand in a very thin film much higher voltage per thousandth of an inch than they will stand in a body; and, in a manner quite similar to paper, the resistance of oil in a thin film is very much greater per thousandth of an inch than is that of oil in a body. So the laying up of wrappings of insulation with the spaces between (because even if they touch there are spaces between) well filmed with oil results in the production of alternate layers of paper and oil film, so to speak; and whether that is the reason or not, the fact is that, so laid up, the insulation is very much higher—the resistance to breaking down is much higher—

and then the oil also serves to prevent air from getting in between the wrappings, so that the sponge action of the [fol. 72] plurality of layers, wrapped one on top of the others, initially coated, is imparted.

So, the conductors having been joined and wrapped with pervious insulation, then a sleeve of impervious material is placed over it, and joined to it by an ordinary plumber's wiped joint at the ends. That is, the sleeve is long enough to extend back over the cut ends of the lead cable sheath and be united to it. Then, the sleeve is filled with a compound which is fluid at ordinary temperatures, referred to as an insulating fluid, and of such a nature as is adapted to permeate the pervious insulating material, and a receptacle is attached to the joint or built into it so that a reservoir of material exists to make good the demands of the cable and of the joint when occasioned either by the bleeding or breathing actions, or by the absorption; all of these being causes referred to as tending to make the cable draw on the reservoir for a renewal of its oil supply.

That, as I understand it, is the joint contemplated by the patent as referred to in Claim 4.

The Court: Mr. Waterman, did I understand that in Fig. 1, No. 10, or in Fig. 6, No. 12, that is the receptacle indicated in Claim 4?

The Witness: Yes. That is what I understand.

The Court: It is called a reservoir, and it is also called other things there.

The Witness: Yes. The specification uses the word "reservoir" chiefly.

The Court: Yes.

[fol. 73] The Witness: The claim uses the word "receptacle".

The Court: Receptacle.

The Witness: Yes.

Mr. Usina: Before proceeding, I should like to offer in evidence the piece of cable which I handed to your Honor this morning.

(Received in evidence and marked Exhibit 20.)

The Witness: I have known Mr. Torchio, patentee of the patent in suit, in a business way for a great many years. He was an engineer of the highest standing. I have known him as being in charge of power distribution for the New

York Edison Company, and one of the officers of the company.

The patent in suit describes three different features: First, the provision of a copper gauze sleeve, within the outside sleeve, and, second, the provision of a compound which is used at ordinary working temperatures and in a certain quantity indicated, and also filling the reservoir, and, third, without illustrating it, the patent describes a construction in which you have an insulating fluid permeating the pervious body or wrapping immediately around the joint, and then in addition, you have a mass of insulating material of greater density around that. That is not illustrated. These three features are segreable and capable of independent use and they are so described in the patent.

Mr. Usina: For the purpose of the record I call attention [fol. 74] to the fact that the patent claims, "The combination of an insulating fluid, permeating the pervious body with a mass of insulating material of greater density around it", covered by Claim 5, and Claim 4 includes neither of these claims.

I offer in evidence a publication entitled, "Joints in high voltage conductor cables", published by the American Institute of Electrical Engineers, on June 20, 1927.

(Received in evidence and marked Exhibit 21.)

Mr. Usina: And an article entitled "Experience with oil reservoirs, for preventing voids in high tension cables", published in the Electrical World of November 19, 1927.

(Received in evidence and marked Exhibit 22.)

Mr. Usina: These, if your Honor please, were submitted with interrogatories, and the defendant agreed that they disclosed their cable joints.

Q. 15. Now, Mr. Waterman, taking these two articles as descriptive of the cable joints installed by the defendant, please explain the construction and operation of such joints.

Before you go ahead, I may interrupt to say that in explanation thereof we have made separate drawings and figures in these publications which I should like to offer in evidence.

(Received in evidence and marked Exhibit 23.)

[fol. 75] Mr. Usina: And Drawing F.

(Received in evidence and marked Exhibit 24.)

Q. 16. You may use these drawings in your testimony. They are drawn from the pictures in the article, by Mr. Waterman, and if he has made any changes, why, they will appear.

A. Before answering the question I perhaps ought to supplement my answer of this morning by referring more specifically to what is meant in this connection by high voltage.

Of course, such a term is relative. But in this particular association, one might say that a cable carrying 15,000 volts or higher would be a high tension cable. That, of course, is an arbitrary line but I mention that as an illustration, because it is at about that voltage that the ionization effect to which this patent refers begins to be a very prominent phenomenon, and therefore gives rise to special insulating difficulties.

Exhibit 21 has to do chiefly with the formation of joints in cables designed for 27,000 volts, and details numerous tests that were made, and finally the construction of the joint as finally decided upon. I think we may go directly to page 966 of Exhibit 21, which shows, in figures 4 and 5, a side elevation, partially in section, of two such joints.

Figure 4 refers to a joint in what is known as belted cable, while Figure 5 refers to a joint in a sheathed cable.

Your Honor will remember that the difference between these two forms of cable is that the belted cable, after having been insulated and put together, and the interstices [fol. 76] between several insulated conductors filled with a suitable filling material, then has an additional wrapping of insulation, of paper, wound around them before the lead sheath is put around them; while the sheathed cable has each separately insulated conductor, wound with copper tape, and in that case the belt, of course, is omitted.

Figure 5 refers to the joint in such a cable. I have had a drawing, marked Drawing E, prepared, marked in evidence as Exhibit 23, which is taken from Figure 5, and is a faithful illustration of the substance of that figure, as I understand it, with an oil reservoir, 17, added at one of the sleeve outlets shown in Figure 5, and this is in accordance with the description found at Page 967 in the first para-

graph, specifically in the eighth line, where the joint is referred to as provided with a collapsible reservoir. This is also in accordance with the second publication, Exhibit 22, which shows several kinds of reservoirs, the one illustrated in Drawing E, Exhibit 23, being illustrated in Figure 3 at the top of Page 1031 of the second publication, attached to one of the oil filling outlets. I may, perhaps, as well refer here to an alternative arrangement shown in Drawing F, which has been introduced as Exhibit 24, and which illustrates another mode of oil supply which is referred to in this second publication, and is substantially an enlargement of Figure 7 of the second publication, Exhibit 22, as found on page 1033, that being a diagrammatic illustration, and Figure 8 which is a photograph of the interior of the manhole. In this instance the same sort of collapsible reservoir is employed as shown in Figure 3; but instead of having one for each joint, which is very difficult to [fol. 77] do, where the cables are set one above the other, a single receptacle is employed, which is connected by a pipe with several of the cable joints, so that one reservoir does for several cables. That is shown in Drawing F, Exhibit 24.

Coming now to the construction of the joint: A section is shown in the lower figure, taken on the line XX of the upper figure, looking to the left, as shown by arrows. Referring now to Exhibit 23. The three conductors are shown at 1, 2 and 3. They are sector shaped instead of round. Both forms are used, but this shows a sector-shaped conductor, surrounded by wrappings of insulation, figure 4, which is the original insulation put on by the manufacturers. Then, additional wrappings, 12, are shown, which are put on in the course of the manufacture of the joint.

The cables, as your Honor will see, have been separated as compared to the closely associated condition in the original cable; that, of course, being necessary for the manipulation involved in the jointing.

The drawing shows that the two sections of cable 6, 6, coming into the manhole from opposite directions have had their lead sheaths removed back from the center, to the point marked 8. The conductors have then been spread, and a short length of each near the center has had its insulation removed, and a copper sleeve, 9, slipped over and soldered to join the cables electrically—that is, to join the

individual conductors of the cables electrically. Then, the adjacent insulation has been pencilled back as shown at 10. [fol. 78] The end looking quite like a paper pencil that has had the wrapping removed for pointing purposes, and the term "pencilled" is derived from the ordinary paper pencil and the method of sharpening it. Then, the short space which intervenes between the end of this pencil insulation and sleeve 9 has a little tape, described as varnished cambric, wound around it, and then varnished cambric at 11, shown by the absence of any shade, has been wrapped over the connector, 9, lapping up onto the pencilled paper, 10, of the insulation. It is described in the article as being but one layer over the connector 9, but it has, of course, been levelled up in the interval between the pencilling and the connector.

Then, over that has been wrapped layers of paper, 12, which extend over the insulation and along the conductor, for a considerable distance on each side.

Now, where the conductor of the cable leaves the lead sheath and is spread out, and the lead sheath ends, is a particularly vulnerable point. This is because of the extreme concentration of the electrostatic field extending from the several conductors to the sheath, which occurs when the sheath is abruptly terminated. To aid in withstanding this pressure, and at the same time form a foundation for a metal extension of the sheath to reduce to a minimum the stresses of the field, layers of insulation referred to as varnished cambric have been built up to form a conical mass as shown at 13 on each of the three conductors. This tapers gradually up to a point near where the numeral 13 is applied, and then tapers more abruptly to meet the paper insulation which has been carried along the cable from the center in each direction.

[fol. 79] Your Honor will recognize, of course, that in this drawing, the left of the center shows all of the elements sectional down to the original paper insulation, whereas at the right there is shown the completed insulation.

Then, over this cone there is extended a metal shield, 14, which is composed of a lead strip or foil which is wound around the conductor, and extends up to the point of greatest thickness of the insulation, 13. This foil is joined with the copper shield which—bearing in mind that this is a

shielded cable—is around each conductor by a lapping of the copper over the lead, as shown at 15. That is at the extreme right and extreme left of Exhibit 23. There is such formation around each conductor. In the application of this insulation as I understand, a tape is applied with the edges butting—that is, a spiral of tape is wound around, but the second turn of the spiral does not lap over onto the first, but approximately contacts at its edge. That is done as I understand, primarily to avoid the little spiral openings that would be formed if the insulation lapped over, one turn on to the one preceding, it being much easier to avoid any air inclusion in a radial abutting of the edges, even if the edges do not quite meet, and it makes the whole accessible to the liquid, which is not only flushed freely over the insulation while winding it, but that continues to absorb the oil which is eventually put into the joint sleeve, as indicated at 18, and which surrounds the individual conductors as shown in both the lower and upper figures of Exhibit 23.

I can explain by means of a sketch what I have just been [fol. 80] saying about the wrappings and the butting of the joints. I have here a rough sketch which shows in the center a conductor, marked 1, and around it, wrappings, marked 12, and it shows the edges of the successive tapes as not quite touching, but with succeeding layers arranged to overlap the abutting joints of the preceding layers so that these joints do not exist in a straight line radially outward from the center.

Mr. Usina: I ask that that be marked in evidence.

(Received in evidence and marked Exhibit 25.)

The Court: You can mark that and substitute a copy.

Mr. Usina: All right, sir.

The Witness: The joint having been completed to the extent thus far described, the sleeve, 7, is applied and joined up by a wiped joint to the lead sheath of cable 6, at each end, and this sheath is shown as provided with two filling nozzles or openings, 16, in Figures 4 and 5 of Exhibit 21. And as shown in Figure 3 of Exhibit 22, I have provided drawing Exhibit 23 with a collapsible reservoir, 17, attached at the right hand filling nozzle, 16. The joint and its lead sheath are reenforced by an insulating tube, 19, which is slipped inside of the lead, and which, while an in-

sulator, is said to be primarily used as a mechanical reenforcement to minimize the liability of mechanical injury to the sleeve:

Drawing F, Exhibit 24, shows a sort of perspective view looking into the side—looking at the side of the manhole [fol. 81] from the center, showing three cables, C, as diagrammatically indicated, with joints, J, and three such joints are shown connected by a pipe, 17a, connecting with the reservoir, 17, and a pipe projects from the reservoir, 17, to the right, which is assumed to go to one or more other joints. I understand—although I don't remember that—it is stated in the article that in practice four joints are connected to a single collapsible reservoir.

In Exhibit 22, there is shown in Figure 4, diagrammatically, a way of adding weight to the reservoir; and Figure 1 shows another form of reservoir used earlier which also has weights, the idea being to put a small pressure upon the oil supply so that the cables are at all times kept under a slight oil-pressure which will assist in the prompt filling of any voids that may tend to occur due to the contraction of the cable when cool, to the disturbance of the conductors by overload or any other cause.

By the Court:

Q. 20. What is Exhibit 23—what is 18?

A. 18 is the oil filling.

Q. 21. Is that the receptacle that you are talking about, full of oil?

A. No. 17 is the receptacle.

Q. 22. 17 is the receptacle?

A. Yes. And 18 shows the oil in the joint which is in communication with the body of the oil in the reservoir, 17. It is all one body of oil, connected through a connection, 16, and filling the entire sheath, 7, and permeating the insulation of the joint and of the cable.

Q. 25. In other words, this cable lays in a body of oil?

[fol. 82] A. Yes, the individual conductors of the cable, that is, are spread out from one another, as shown in cross-section in the lower figure—and covered with wrappings of insulated material, and are then completely immersed in oil and the oil has access to the filling of the cable from this body of oil, which is, 18k in here, which is

continually replenished by constant communication with the receptacle [redacted]. It therefore results, first, that if in the cutting away of the sealed ends of the cable and the cutting back of the lead sheath to a sufficient distance to permit of all this insulating wrapping, the cable has bled—that is, has lost some of the contents originally in the insulation of the cable—the filling of this sleeve, which is done by continually pouring in and allowing it to overflow until all air has been carried out by the oil; also it is put in hot so that all moisture is carried out as well—also fills the voids at the ends of the cables and the supply is then kept under pressure by filling reservoir 17, and as the cable continues to absorb, as it inevitably does, it takes oil from the shield 7, and reservoir 17, to make good such deficiency.

Then, during the process of operation the cable is heated and cooled. As it is heated, it tends to squeeze the oil out, and as it cools it tends to suck oil in; and that is the phenomenon known as breathing; and for all those purposes, the presence of a superabundant supply of oil enables the cable to operate without the actual formation of voids in the cable or in the joint construction, and therefore avoids those ionization changes which lead to the early breakdown of the cable or the joint at points where they occur.

It is evident that there is involved in this joint construc- [fol. 83] tion shown in Exhibits 23 and 24, the presence of an electric cable, which is shown being broken away at 6, at each end, and line conductors inside of the cable and a body of pervious insulating material enclosing the joint between the ends of adjacent cable sheaths. This material wound upon the joint, as I understand it, is pervious, notwithstanding the fact that it is in part composed of varnished cambric, which would hardly be called pervious in the ordinary sense that oil will go through it. It is quite certain very little oil would go through it that way, because varnished cambric is fairly resistant to oil. But the varnished cambric is wound up with oil between its layers, as I understand the construction, and therefore consists of a large number of films of oil interwound with the varnished cambric, so that it is a structure which is pervious in virtue of its oil-coated laminations, and is therefore capable of both exuding and drawing in oil.

Then, the central portion of the joint structure is paper, which is wound in the middle over one layer of butted jointed cambric. That, of course, is not impervious, but, on the contrary, is pervious to the oil. Then, over that is wound the mass of paper, 12, which is a succession of layers also wound up in oil. Whether paper that has been impregnated with oil is pervious or not in the sense that oil would go vertically through it, is doubtful. But wrapped up in a mass or in this way forming layers having oil films between them, it is what the patentee himself calls pervious material, as I understand it, and the oil has access by an infiltration process, either to leave or to go into the mass [fol. 84] of insulation wound upon it, and to eventually work its way into the cable and out of the cable as the 24-hour cycles of contraction and expansion occur.

I find in the exhibits which have been shown me, particularly 22, justification for my understanding that the oil flows into the varnished cambric wrapping on the cable ends of the joints. Exhibit 22 deals at a good deal of length with this matter of the migration of the oil in the cable and in the joints and details—. I have reference to page 1033, near the bottom of Exhibit 22. On page 1029, in the second column, second paragraph, it is stated, with reference to the type of oil reservoir shown in Figure 1, when filled with petrolatum or a mixture of petrolatum and transil oil, "They served exceptionally well to compensate for volume changes incidental to temperature variations and absorption of the compound by the cable. These crude reservoirs have since been replaced by our present day methods of replenishing oil by a process of piping."

Q. 29. I call your attention to page 1033, next to the last paragraph in which, referring to a future installation, it is said, "These joints will be oil filled and fitted with bellows type reservoir", and goes on to describe the operations. Do you find in there any indication of whether or not the lapping about the ends in the cable joint is pervious to the oil?

A. Yes. There is, however, one passage here which details the experiments which were made, and makes the definite statement that the experiments show conclusively that the oil does migrate. That was the passage I was looking for. The passage that you refer to, refers to the

[fol. 85] insulation of three feeders which were intended to be primary feeders, on which the integrity of the system depended. It says, "The importance of these can hardly be over-estimated, hence, the use of the very best cable and insulation and jointing methods of the highest order. These joints will be oil filled and fitted with bellows type reservoirs. It is expected that with the assurance of a well saturated and filled cable and joint system, under constant pressure, slightly above atmospheric, very satisfactory results will be obtained. The use of fairly light compounds in the cable will facilitate transmission of pressure through the cable to the reservoir. It may at the same time allow an appreciable oil flow, due to static head."

Page 1029 refers to the installation of a collapsible bellows type reservoir, and to the changes in the contents of these reservoirs. It says, "At the end of this time considerable evidence substantiating migration theories was obtained. Many of the receivers were entirely devoid of oil; other contained large voids." That is, they were partially empty. It goes on, "The results were in entire agreement with observations of a different character, for example, (1) collapse of joints was being reported by some companies"; this would mean that if the joint were of the old type, and the cable sucked the oil away from it, a partial vacuum would be left, and the air pressure on the outside would tend to collapse it; "(2) the local system experienced a great number of joints failures apparently due to lack of compound despite the fact that filling was once complete; (3) joints could be refilled—that is, would allow additional compound at six months intervals. (Incidentally this practice gradually reduced the number of failures obtained.) Only one conclusion could be reached, and that was that compound did migrate."

[fol. 86]

The evidence of the article, therefore, is quite complete. It is, in effect, that the action which as I said are set forth in the patent in suit as "breathing" and "absorption", did take place in the experience of the writer of these articles, on the Brooklyn system.

Comparing the Brooklyn system, as outlined in these articles, with Claim 4 of the patent in suit: There is obviously an electric cable comprising a sheath, the sheath being shown at 6 in Exhibit 23, and a line conductor having a joint. The joint is shown at 9, in the upper view of

Exhibit 23. The three conductors are shown at 1, 2 and 3 in the lower figure of Exhibit 23. There is a body of pervious, insulating material enclosing the joint, which is the initial paper wrapping of the cable shown at 4 in both figures and the additional wrapping of cambric and paper as indicated at 12. There is a sleeve of impervious material, namely, the lead sleeve, 7, which is of much greater diameter than the pervious material on all of the cables combined, and it encloses the joint, and is sealed to the cable sheath at each end by a plumber's joint, where the sheaths 6 and 7 are united, and there is a receptacle which in the particular construction shown in Exhibit 23 is the collapsible reservoir, 17, attached at 16, to the sheath, and which in Exhibit 24 is receptacle 17, united by a pipe, 17a, with several joints. And there is an insulating fluid which is an oil, referred to in the article in one of the passages I read, which is adapted to permeate the pervious body [fol. 87] and is contained in the receptacle, 17, and in the space between the insulation and the sheath, 7, so that the whole structure of the joint is em-ersed in oil under such slight pressure as the reservoir exerts upon it in the two constructions, in Exhibit 23 and Exhibit 24. As I understand the description of the patent, as particularly set forth in Claim 4, therefore, it relates to such a construction as is shown in Exhibits 23 and 24, showing the defendant's joints.

Having been asked when he considers the overlapping layers of varnished cambric in defendant's joints, what he knows about the space between the successive layers being sufficient for the passage of oil, the witness stated: Of course, when the surfaces of the insulation material, being paper or cambric, are coated with the oil, so that each layer is separated from the one on top of it by a film of the oil, the capillary action that always arises in such cases where the interstices are wet by the material, causes oil to be drawn in, if by compression it has been previously squeezed out or permitted to be squeezed out, if the cable—the interior is expanding, as the breathing action contemplates, notwithstanding the fact that the oil may not be able to go radially through either the paper or the cambric. The butt joint construction provides a means both for it to exude and also to draw in, travelling through the films between the layers. The article makes it very clear that

whatever the mechanism may be, it did happen, as a matter of fact.

It probably would be very hard to tell at any one point what the pressure is from the outside on the oil when the [fol. 88] cable cools and contracts so as to draw oil into it. I suppose that the pressure that is due to the reservoir probably would not be over two or three pounds. The pressure due to the cable being quite nearly air free could rise from that point up towards the 14-7/10 pounds of atmospheric pressure. If the shrinkage was sufficient, approximately atmospheric pressure might be encountered acting through the reservoir to force the oil into the cable and the interstices in the joint. And the pressure in the opposite direction might easily be greater. It might easily be sufficient to expand the lead sheath.

By the Court:

Q. 37. What is the date of this Exhibit 21? 1927, wasn't it?

A. June, 1927.

The Court: The other was 1927 also?

Mr. Usina: The other was 1927 also. They are descriptions of defendant's joints.

The Witness: I have read the record in the previous suit on this patent, Metropolitan Device Corporation against Cleveland Electric Illuminating Company.

Asked: How do the joints of the present day compare with those of the defendant in that Cleveland suit—what difference is there, and what resemblance, the witness stated: The cable, as I recall, that was involved in the Cleveland case, was a single conductor cable, instead of a three conductor cable. The voltage was considerably higher; I don't remember exactly—I think it was 66,000 volts, a very high voltage; and the joint was insulated with [fol. 89] paper wrappings put on—wound on, the edges abutting. I don't remember that there was any cambric used in that construction. And then, surmounting the joint was a collapsible reservoir, just as shown on Exhibits 23 and 24. I don't recall whether it was connected by piping as shown in Exhibit 24 or directly connected as shown in Exhibit 23. At any rate, such a reservoir was connected. The filling was petrolatum, which is very much like vase-

line, and which is fluid at the ordinary working temperature of the cable. I don't know what the melting point is, but it is not very much above body temperature. And, of course, it is never very hard; it is always soft.

Cross-examination.

By Mr. Neave:

Asked what experience he has had as a manufacturer and constructor of cables for power lines, the witness stated: None at all.

Asked what experience he has had in the making of joints, the insulating of joints for these power lines, the witness stated: None, for high power tension circuits.

Asked if he has had any experience in making a joint for power circuits, the witness stated: The only high tension—the only cables that I installed were 600 volt cables; ordinary electric railway cables.

I don't remember whether in the Torchio patent, the words power cables are used or not. But it is evident from the disclosure that that is what it means.

Asked what is there in the disclosure that makes him think that is evident and why wouldn't it apply to any conductors, [fol. 90] cables for carrying electricity of any volume or of any voltage, the witness stated: In the first place, the construction shown is one that applies only to high tension cables, and in the next place, it refers to difficulties which arise only with high tension cables, that is, under low voltages, the existence of a void, as long as water is kept out, is of no particular consequence. In fact, no one would go to the construction here shown for a 600-volt cable, for example.

I don't know of any cables in which the conductors carry current at very high voltage, but very little current. There is nothing to stop anyone from doing that. The voltage is the critical factor which is here involved, and the current is incidentally involved, because, given the voltage, then the amount of power varies with the current. And, of course, these cables are normally expensive. One cannot put them in unless there is going to be a lot of power distributed.

Asked how high does the voltage have to be in the conductance of a cable in order that the cable may be a power cable, the witness stated: Well, the lowest, of course, the

Edison cable is on a 110 to 220 volt basis. It develops a large amount of power, but they are not high tension.

Again asked how high does the voltage have to be in order that the cable may be a high tension or a high voltage cable, the witness stated: All those things are relative, of course. It is not so very many years ago that one or two thousand volts would have been considered pretty high. But the patent really gives you its own indication of what is meant, by the nature of the troubles that it refers to. [fol. 91] And as I have said, while any dividing line is arbitrary, I would take 15,000 volts as marking what I would call high tension cable, because it is at about that voltage where the ionization becomes so bad. Below that, the difficulties are less; that is, they grow rapidly less below 15,000 volts.

Asked, does not the ionization occur at 14,000 volts, the witness said: Of course, you can keep on whittling down, of course. It gradually grows and does not become really serious until you get up in the neighborhood of 15,000 volts.

Asked if he would say a 13,000-volt cable was a cable of the kind referred to in the patent, the witness stated? I don't see why I should find any limit. I should think it might be.

Ionization occurs at 2300 volts if the vacuum is high enough. Of course, the ionization of the air is dependent upon the pressure, and if the air pressure in a void is quite low, it will begin earlier. The earlier it begins the lower the voltage; the later it begins the higher the voltage.

X Q. 53. Of course, the patent does not purport to state that Torchio discovered that oil is an electrical insulating liquid. That was known before Torchio?

A. Yes.

X Q. 54. Torchio does not purport in his patent to be the first to use a cable such as is shown in your drawing, Exhibit 16, does he?

A. No.

X Q. 55. And he does not purport to have been the first one to have had insulating oil in the cable, or to be the first one to wrap the cable itself?

A. No, in the passage beginning at line 51, where he talks about ordinary joints, he is talking about cables, in which, as I understand it, there was oil impregnation.

X Q. 56. He does not purport to be the first one to make joints in cables, does he?

A. No.

[fol. 92] X Q. 57. Nor was he the first, according to this disclosure, to make or use pervious wrappings in joints, was he?

A. No.

X Q. 58. And he was not the first to use a sleeve enclosing in the joints, hermetically closed, and connected to the metal sheath of the cable?

A. No.

X Q. 59. And he does not purport to have been the first to use some kind of insulating material contained in the lead sleeve and surrounding the joints, does he?

A. Oh, no.

X Q. 60. And he was not the first to suggest making these sleeves—I suppose you call them—the thing that surrounds the joint, larger than the sheath of the cable itself, the lead sheath of the cable itself?

A. No.

Asked how one of these lead sheaths is put on the cable, the witness stated: It is done in various ways. But the sleeve is ordinarily slipped over and slipped along on the cable, and the joint made, and then slipped back into place and beaten down until it fits the lead covering of the cable, and then the joint is wiped. One way of doing it is, if you have the ends of two cables you want to join together, you take your lead sleeve and slip it over this one, for instance, and push it out of the way, and then make the joint and pull the sleeve forward.

X Q. 63. From the drawing here, I don't see how you could have done it that way, because the joint as made up is very much larger than the ends of the sleeve. How did he get it on?

A. Well, that is always true. The sleeve is put on as a cylinder of the full diameter that it is going to be, and then, if you have ever seen a plumber working on a piece of lead [fol. 93] pipe, you know how it is done. He taps it and gradually shrinks it around the ends of the lead sheath of the cable, until it is drawn down to the correct size.

The Witness: In my direct examination I spoke of a copper sheathed cable; that is, a thin strip of copper wound

spirally on the wrappings of the cable. The strip of copper is ordinarily perforated.

X Q. 66. Now, in the Torchio patent, at page 1, line 95, he speaks of the insulating oil or other liquid which is fluid at low temperature. What do you conceive he means by low temperature? That is, how low?

A. Oh, low enough so that it accommodates—it flows back and forth with the breathing. I suppose that might get down to ordinary room temperature, perhaps.

X Q. 67. That is, it could be elevated above room temperature. I suppose that is what you mean?

A. Well, high and low are relative terms, and you have to interpret them from the context. Now, he is talking about such temperatures that the material will flow in and out as called for by the breathing of the cable; and low temperature means low temperature for a cable. That is, low temperature compared with reference to heat in the cable when operating. That is, the temperature of the cable, when carrying a full load, is about 150, 160 or 170.

Asked, is it that he wants a compound that is liquid or fluid at temperatures of 150, 160 or 170, the witness stated: Certainly, but he says, as distinguished from 150, 160 or 170, "at low temperatures." That means that the oil is so fluid that when the cable cools down this oil can freely go back into the cable, in the breathing cycle.

[fol. 94] X Q. 71. It is not sufficient to be a fluid at ordinary working temperatures of the cable?

A. Singular or plural? Ordinary working temperatures would include, let us say, from maybe 50 or 60 degrees up to maybe 160 or 180 degrees Fahrenheit. I think he contemplates something which shall be able to respond to the contraction and expansion of the cable, within that range.

X Q. 72. That is, the term fluid or liquid does not necessarily mean something that will flow, but something which will move in and out of the cable, migrate in and out of the cable soft enough to do that; is that the idea?

A. As to the last part certainly, yes. I don't know just what your conception of something that will flow is. If you have in mind flowing in a stream as from a pitcher, I don't think that has any resemblance to the rate of flow in the cable. It is not like pouring a glass of water.

X Q. 73. No. I don't think that vaseline is something that I could pour out of a pail. I suppose I could pour it

if I held it upside down long enough. But I don't conceive that vaseline, or anything of the consistency of vaseline at room temperature would move in and out of a cable, would it?

A. Yes, probably it would, but not so readily as a thinner oil.

Asked if Torchio says anything about using a very light oil, something that would pour as water would pour, the witness stated: He says, "I fill the sleeve and reservoir with any suitable insulating oil or other liquid, which is fluid at low temperatures, and preferably of a character which will combine with the material used in the body of the cable." I take it that he means something that is sufficiently liquid within the limits of use of a cable, which [fol. 95] may perhaps be from 50 to more than 160 degrees, so that it will move or migrate in the cable in response to the breathing forces.

X Q. 75. Do you remember that it appeared in the Cleveland case, in the opinion of the Court, that that compound that they had used was normally of the consistency of vaseline or jelly? That is what you call fluid, isn't it, for the purposes of the patent?

A. That is what the Court called fluid.

X Q. 76. Do you agree with it?

A. Yes, I think that is about the limit, Mr. Neave. In a duct system, the oil practically works through a limited temperature range. The duct temperature therefore may easily be always within a range of 90 or 100 degrees, from the upper limit, whatever that may be; and a material like vaseline would, under those circumstances, be a fluid within the meaning of the patent, as I understand it. But if I were to install a cable in Greenland, where the temperature might get very low, then to comply with the same instructions, I would have to use something that was less likely to grow stiff and have its flow unduly hampered. In other words, the patent description itself takes into consideration the circumstances of use. I don't think it is right that you could use X degrees as the limit. It may depend upon the set of circumstances and some other limit may be used under another set of circumstances, all depending upon the conditions of use and the paragraph itself is a complete definition.

By the Court:

Q. 77. In other words, the compound should be fluid enough to migrate?

A. To migrate under the influences tending to force it.

[fol. 96] Q. 78. Regardless of what the compound is?

A. Yes.

By Mr. Neave:

In the course of my direct examination very likely I may have said that there was a continued desire of the cable for more oil. As a cable grows old is apparently gets drier and drier, even though there is no change in it, there is a certain continued absorption that occurs.

X Q. 80. Throughout the life of the cable?

A. Yes. But you are pressing me too far on that, because I don't know. But I understand that at any rate, for a long time——

X Q. 81. This is irrespective of what you call the breathing or the bleeding?

A. Yes, absorption and breathing are different things. One is a cyclical event, a response of the cable to the load it carries, and what it is doing——

X Q. 82. Now, this absorption, which I understand is the other feature that you are speaking of—I understand you to say that if I have a cable made that was well impregnated with oil, and put it into use, perhaps if I put a joint in it I might bleed out a little of that oil. But let us suppose I fill that up again. Let us suppose that cable in use. Although it has been full of oil, it wants to take more oil, and it keeps on doing that indefinitely——

A. Yes. There are three factors involved. One is the apparent tendency of the insulation to absorb; secondly, the tendency of the insulation to shrink; and, thirdly, the action of the load in stretching the lead sheath, an overload thus making more room.

X Q. 83. In the Torchio patent, as I understand it, he fills his joint with some kind of insulating liquid or fluid [fol. 97] and then seals it off; I mean, closes it hermetically tight, doesn't he, by screwing something in the top?

A. Yes, it has to be closed. He closes, however, the reservoir.

As shown in figure 6 he has built his reservoir into his joint and closes it there.

The patent says, in either case the sleeve, or the sleeve and reservoir, is full of oil or other insulating liquid, to start with.

X Q. 87. Now, let us suppose that we have made our cable, made our joints, filled the sleeve full of oil, sealed it off hermetically, and then we turn electricity on to the conductors of the cable, so that they carry a heavy load. They warm up, don't they?

A. They do.

X Q. 88. And that heating being greater in the interior, as you have expressed it, than at the outside of the cable, causes a pressure to be exerted and tends to expel oil from the cable—I think that is what you say. Now, where does that oil that tends to be expelled, go?

A. If there were no other way, the only thing it could do would be to stretch the lead.

X Q. 89. The lead of the cable or of the sheath?

A. Both. That is what it would do. But as a matter of fact, one of these articles, the second one I believe it is, Exhibit 22, goes into that a considerable length. As a matter of fact, what happens is that in the best made cable and the best filled cable, there are always in the twisted conductors considerable voids, and what happens, as a practical matter in the cable, and as analyzed mathematically in one of these writings is that that air under compression acts as a spring, and of what you have to be sure about, is that the pressure produced is not too great, so that there is any danger of bursting anything.

[fol. 98] X Q. 90. Now, this Torchio cable that we have made, we have put a load on it, and we have caused something to expand, and we have expelled oil from the lead sheath of the cable, and then we turn off the current, and the cable cools down; or we have a lower load as the cable cools down. Then the cable will tend to such oil, won't it?

A. Yes.

It will suck it from the joints, and through the joints from the reservoir. And then, as the cable sucks oil from the sleeve, at the joints or the reservoir, it produces a partial vacuum in the sleeve. It tends to force the oil into the cable.

X Q. 94. No, no; the vacuum won't force it in. The cable is trying to pull oil from the sleeve of the joint into itself?

A. Yes, the vacuum is in the cable. That vacuum makes a pull on the oil that is in the sleeve and the reservoir.

X Q. 96. That oil from the sleeve and the reservoir is not free to flow into the cable, is it? It cannot flow without leaving some void spaces in the sleeve, can it?

A. It can, till the pressure is equalized, certainly.

X Q. 97. Then you get to a point where you have a suction due to the cable and a suction due to the void that you have made in the sleeve. If those two balance each other you won't get any more flow?

A. There won't be a void in the sleeve. There might be a void in the top of the reservoir. That is why the collapsible reservoirs are an advantage.

Torchio does not say anything about that or about a collapsible reservoir. That interchange takes place always until the pressure is equalized. When expansion occurs pressure goes up in the joints and in the reservoir. But [fol. 99] when the contraction takes place, the pressure is lowest in the cable.

X Q. 99. The Torchio reservoir, so-called, is absolutely nothing but just a larger sleeve, is it?

A. I don't know what you mean by that. It is a reserve supply of oil. I don't see that it makes any difference how you define it.

X Q. 100. All right. Look at the drawing in the patent. Does the reservoir in figure 6 act any differently from the reservoir in figure 1? Does it have any different function?

A. Yes and no. If it held the same amount of oil, then it would have the same reserve supply. If the height of the oil extended the same height, it would have the same hydrostatic head. If it does not, it would have a different hydrostatic head. Therefore, whether they are alike or not, would depend upon the exact details of construction.

Torchio treats the two alike for the purposes of reserve supply.

Asked what quantity of oil does the Torchio patent teach to use, the witness said: I don't know that it teaches anything definite. It could not very well. Different cables would use different quantities. If you take a large cable—they figure for a cable about the size you are using here—I think they figure something like a half a gallon for a distance between manholes, as being the amount that the cable is likely to take up in each breathing cycle, and as the cable keeps on taking up oil indefinitely, you have to fill them every once in a while.

The joints in the Torchio patent are filled as often as they need it. I think he leaves it to common sense to tell one when they need it. He does not have to use enough oil to take care of the cable throughout its life.

[fol. 100] Asked if you can fill it whenever you want to, the witness said: Well, obviously a thing of that kind is a practical matter. You have got to inspect the cable once in a while anyway. After six months in some instances you might have to inspect the cable. If you found that too much oil has gone out of the reservoir you fill it up.

I do not know at what temperature paraffin is liquefied. It is a little less than the boiling point of water. I know it can be liquefied in boiling water. It is something under the boiling point of water; I don't know how much. Of course, it freezes at quite a high temperature, too. That is, to say precisely—what is the melting point,—it is not normally in a soft liquid condition, but in a brittle condition.

X Q. 110. But it becomes fluid at 120 degrees, or something of that sort, doesn't it?

A. I don't remember. I will take your word for it.

X Q. 111. You must not take my word for anything of the sort.

A. I can look it up for you. I was thinking it was 160 degrees. I will have to look it up.

X Q. 112. Will you do it? Is it convenient for you to do it?

A. Yes, I will do it.

X Q. 113. Now, these cables which we have been talking about, which the Brooklyn Edison has here and in which it makes joints, what are the insulating materials in the cables, do you know? Just what kind of a cable is this that we are talking about as an infringement? You gave a drawing of a cable which we have here—I don't think you said that is the defendant's cable. How many conductors to the defendant's cable and what kind of insulation has each conductor?

A. If you take these articles saying what the difference [fol. 101] is—it has a three-conductor cable of—about such as we exhibited in evidence, I believe.

X Q. 114. What is the insulation of it?

A. What?

X Q. 115. What is the insulation of each conductor?

Mr. Usina: Exhibit 20.

A. I understand the insulation is paper and the filling is jute.

X Q. 116. No varnished cambric in that cable?

A. Not so far as I know.

Referring to the defendant's cable and joint—and asked does the migration of oil from the sleeve and reservoir at a joint mean that the oil goes through the joint wrapping the witness stated: I think undoubtedly it does to some extent, but it also migrates in the jute filling.

X Q. 118. Still these three conductors, separated as they come out at each end of the cable, at these crotches—is that where the oil goes into the cable?

A. Well, my opinion is that does that and also keeps supplied the oil film in all the layers of the insulation.

X Q. 119. You have referred in this paper, Peterson's Article Exhibit No. 22, to the absorption of the compound by the cable, as expressed there; and the migration of the compound, and to some portion which would seem to indicate that the compound went from the reservoir into the cable. That would be entirely consistent with the idea that the compound got into the cable through these crotches at the ends of the cable where they come into the joint box, rather than through the insulation at the joint, wouldn't it?

All these statements would be consistent with migration through the crotch joint?

[fol. 102] A. Those statements alone, I should think might, yes; but the fact that the cable did not dry out, shows that is not the only route.

X Q. 120. Well, if it goes from the receptacle into the cable through the crotch, the cable won't dry out, will it?

A. Well, if it cannot all go through or into the layers of cambric, then at every cycle of breathing you have oil squeezed out of your paper and if it does not tend to go back, the cable is very quickly dried out in every part of it. If you lose the oil film you get the dielectric strength only of your paper. Of course, you must not forget that all anybody can know about what happens in a cable is a matter of inference, but when you find that a cable which has been dried out and is only good for 13,000 volts, becomes again suited for continuous use at 27,000 volts, after it has had these oil reservoirs on for a while, then you know that that dried out insulation has had oil migrating through between

the layers and renewing the oil film. This should be an extremely positive proof of migration through the insulation.

X Q. 121. As I understand, that oil from the reservoir goes into the cable and keeps all that nice and oily. Now, I am talking about the insulation of the joints, and you will remember that there is a varnished cambric wrapping at the joints. You would seem to indicate that where there is breathing and the cable responds and forces or tends to force oil into the joint box or sleeve, that the oil is forced through the interstices of the various wrappings of varnished cambric. Now, it seems to me that the oil comes from the cable into the joint box through these crotches at [fol. 103] the end of the cable where the cable enters the joint box and not through the varnished cambric wrappings?

A. Unquestionably between both of them.

Asked how he knows that any comes through the varnished cambric wrappings or whether any is taken up by them the witness said: The article makes it perfectly clear that the old cable was revived. You could not have that result unless the oil went through the laminae of the insulation.

X Q. 123. It went into the cable, then. But why couldn't it get into the cable through the crotches and not through the varnished cambric?

A. Maybe I misunderstood you. I thought you were talking about the flow of the oil through the jute filling as distinguished from the wrapping.

X Q. 124. Through the jute filling as distinguished from flowing through the varnished cambric wrapping. You can get oil into your cable without going through the varnished cambric wrapping at all, can't you?

A. Oh, yes, probably to some extent. I don't think there is any question about the fact that it goes both ways.

Asked how he knows that it goes through the varnished cambric the witness said: Well, the method of applying it makes it certain that it is just as easy for it to go in and out of that cambric as it would be to go in and out of paper. And in the next place, as the joint is described, all the middle part is not varnished cambric at all; it is paper.

By the middle part I mean that part which in Figures 4 and 5 is marked D, and which in my drawing, Exhibit 23,

is marked 12, and which is described in the legend accompanying the drawing as "paper tape." When the cable is [fol. 104] first exposed, it appears that it is wrapped with varnished cambric. I mean, when the lead sheath is first removed, each conductor is apparently wrapped with cambric. That is a temporary matter—that is during the construction. Then, the conductors are joined, and the little space at the end of each conductor is nicely filled up with varnished cambric tape; then a layer of varnished cambric is put over the whole. The next step is to pencil the insulation, leaving exposed all the layers of paper; then they remove the varnished cambric, A, to take a certain distance from the joint, said to be three and a half inches from the pencil, and also one layer of the original paper is removed. The purpose of that is that it is regarded as desirable not to have any paper left in the joint that has had anybody's hands touching it, because the hands are likely to convey moisture and perspiration or soil of one kind or another, and therefore one layer of paper is taken off, and then the paper insulation, which is marked D, is wound up on it, being the entire body of insulation which in Exhibit 23 is marked 12.

X Q. 130. So, no oil would have to go through the varnished cambric tape; is that so?

A. Would not have to, no. It would have a perfectly free access to all the cable without it.

X Q. 131. Access where?

A. Through the joint or through the crotch between the conductors, the same way that it ever gets through wrappings of paper—that is, through the butted joints, wherever the layers—the film between the layers of paper, has a discontinuity. In this case oil can run through all the layers. It can fill the exterior of the layers down to the center and have access to each layer, if it goes through [fol. 105] each succession of butted joints, of which I have made the little sketch on yellow paper. It shows how the joints are small discontinuities at the surface of each layer. The fluid works its way through those joints and replenishes the individual films and individual layers as it travels. If you put a constant pressure on that and expect it to work, it would not happen.

I did not draw the sketch marked Exhibit 25. Mr. Usina asked me to draw one, and I said I would just as leave

use his. The straight horizontal broken lines marked 12 are supposed to represent cross sections of superimposed layers of tape. It is my view that that tape is a varnished cambric. And the oil, while it might not go through the varnished cambric material itself, still it will go through the whole mass of varnished cambric material, because it will take a tortuous path between the layers, and it will do the same thing, whether it is varnished cambric material or paper.

X Q. 136. Suppose this to be varnished cambric material, do you think these lines 12 are drawn properly. Do you think that when wrappings are made of tape you have more overlap as between the butts of successive layers, as shown here?

A. Well, I don't know about that.

I would expect, with a three-quarter inch tape, the overlapping of one joint over another is a quarter of an inch overlap.

I have no doubt at all that oil would get through the varnish cambric so laid. I have not made any tests of that. I may emphasize that. I don't know how one could make a test. The evidence is that this joint stays in perfect condition, a first essential of which is the maintenance of that film of oil.

[fol. 106] Asked if he refers to that film of oil, and it is not maintained there, that there would be good insulation there because that is all surrounded with oil the witness said: No, an important part of the insulation is the maintenance of the oil film. The maintenance of the layers of insulation of oil film, as I understand it, is very important.

In this particular type of Brooklyn Edison joint that I am referring to here, in Exhibit 21, it appears in the article that early in the first joints, they had petrolatum, and later, an oil——

I never saw any joints of the Brooklyn Edison Co. except to see the outside of them. I could not tell from the outside just what the inside was. I went to the Brooklyn Edison and went to some manholes and looked at some of the joints. I don't know from any tests that I made whether oil or petroleum was being used at that time. I don't know anything about the Edison joints, where, along the whole length of each of the conductors in the joint box

varnished cambric tape is wound on the outside of each conductor. I have no information regarding such practice.

Brooklyn, N. Y., April 19, 1932.

Met pursuant to adjournment at 10:30 a. m.; present as before.

Frank N. Waterman, Cross-examination continued by Mr. Neave:

The Witness: I found out that the melting point of paraffin is 149 degrees Fahrenheit, as given by Penders Handbook; 65 degrees Centigrade.

[fol. 107] X Q. 149. We were talking yesterday about a cable cooling down by having power turned off or by a lessening amount of power put on, and the resultant tendency of the cable to suck oil from the joint box. I think you spoke of that as a vacuum in the cable. How much of a suction or vacuum did you find out there would be? Of course, it is not a vacuum, it is just a reduced pressure, I suppose.

A. A partial vacuum. I do not remember, Mr. Neave. I think those figures are available somewheres, as the measurements have been made, I believe, but I do not remember; a few pounds.

X Q. 151. What does that mean? What would that be in inches of barometric measure? Perhaps I should know, but I could not translate that in my mind.

A. 30 inches, or a trifle less than that, ordinarily represents air pressure of 14.7 pounds. I cannot say much more accurately than to say a few inches.

X Q. 152. To the extent to which a vacuum or a partial vacuum exists in the cable, to that extent the efficiency of the cable is lowered, is it not? That is, the breakdown pressure, is lowered the air pressure is reduced?

A. As to the actual pressure at the points where there are voids, that is probably true.

X Q. 153. That is, if you reduce the pressure at a void you are more likely to have a spark going across it?

A. It ionizes more readily, of course, as the pressure is reduced.

The Court: Mr. Waterman, in this Exhibit, I think it is 22, page 1032, they are talking about, this Mr. Peterson of

[fol. 108] the Brooklyn Edison is talking about certain experiments. Now, it said oil was found 20 to 40 feet back from the joint; that is on page 1032.

The Witness: Yes.

The Court: About the middle of the page, on the right hand side.

The Witness: Yes.

The Court: Oil was found 20 to 40 feet back from the joint. Does that mean this sucking arrangement had pulled the oil back that far?

The Witness: Yes, it means that the oil had migrated to that extent; and it appears from the total reading of the articles that it eventually went much further than that, because it completely impregnated the whole cable with oil where the distance from the manholes was probably of the order of 300 or 400 feet.

With the form of joint sleeve and receptacle of the Torchio patent, it would be possible for the oil there contained to move back 30 or 40 feet in the cable. I do not see any reason why it should not.

Asked if he had ever made any trial to see how much oil could possibly get out of that receptacle and sleeve, the witness said: Well, my understanding is from looking up information on that subject, that about half a gallon of oil is all that would be taken from the joint if it filled one length of the cable between manholes.

X Q. 156. You think that with Torchio's form of arrangement as shown in the patent, you could get half a gallon of oil out of that sleeve and receptacle?

A. Do you mean to ask whether it would have that much oil to spare?

[fol. 109] X Q. 157. No, let us suppose he has got more than that; could you get it out into the cable.

A. Surely.

X Q. 158. There is no vent?

A. This article here speaks of the suction being so hard as to collapse the shell.

X Q. 159. Yes.

A. Of the oil; that is at the top of page 1030.

X Q. 160. That does not get the oil out, it just destroys the whole thing.

A. That takes the oil out. It is because the oil has gone out that the vacuum exists such that the superincumbent

air pressure on the outside is sufficient to overcome the strength of the lead.

X Q. 161. Of course, you do not visualize, do you, the Torchio joint arrangement as shown in his patent as one in which the receptacle and sleeve are going to collapse?

A. No, but that is merely evidence of the extent to which the cable exerts a suction.

X Q. 162. Yes. If your joint box and receptacle of oil collapsed you would thing the whole thing was not working very well, would you not?

A. I should not expect it to collapse, but if it did, I would do something about it, surely.

Asked whether he would do something over than merely replacing what he had before, the witness stated: Yes. Probably I would make the reservoir collapsible. That is what the Brooklyn Edison Company has done.

X Q. 165. It is not what Torchio has done, is it?

A. He does not show a collapsible reservoir.

Redirect examination.

By Mr. Usina:

R. D. Q. 166. Would a person skilled in the art have any [fol. 110] doubt about how to avoid difficulties in the first expansion and contraction of the cable after making a joint according to the Torchio patent?

Mr. Neave: I shall have to object to that, your Honor.

The Court: I did not hear it.

Mr. Neave: I do not mean in insult Mr. Waterman, at all, but he said he is not skilled in the art of cables. He has frankly said so.

The Court: I did not hear the question. Will you repeat it?

Mr. Usina: Yes, if your Honor please.

The Court: All right; we will hear the question.

(Question repeated by the reporter.)

The Court: Would you feel qualified to answer that?

The Witness: I know what the practice is to avoid that difficulty in ordinary cases, yes.

The Court: I will allow it. Objection overruled, and give you an exception.

A. The practice, as I understand it, is not to close the joint permanently until after it has been through several cycles. It is watched for some time, and when it has reached a stable state, then it is sealed; and that gives an opportunity to tell just what space is necessary to accommodate different variations of volume. That is very simple. It is very obvious to me, and I think it would be very obvious to anyone skilled in the art.

I do not think it is necessary that the reservoir be [fol. 111] made collapsible in order to make the Torchio joint work. I think that is just one easy way of getting results.

Asked would the defendant's joint Exhibit 21, be considered in good order if oil were not maintained in films between the layers of the varnished cambric that are wrapped about the conductor, the witness said: It would not. The oil films between the layers of the insulating material are quite important parts, are essential parts of the insulating quality of the wrapping. If those films of oil were found to be lacking in any joint, the joint would be defective. The joint would be weak electrically.

I have no doubt about the possibility that oil could be maintained on such a thin space as would exist between two wrappings of varnished cambric, put on tightly, as these are, because oil is notoriously capable of forming extremely thin films. We all know that from seeing oil films on water, which, of course, are extremely thin. I have no doubt whatever that there can be maintained and oil film between these layers of varnished cambric.

Asked whether that oil film can flow slowly through the passages between the layers of cambric in and out of the cable, the witness said: Unquestionably, it provides a continuous conduit for capillary action, and it is not material what the thickness is, because oil films on water are of the order of a wave length of light in thickness; so it would be measured in units of 10-5 inches obtained by dividing one inch into 100 parts, and then dividing each of those into 1,000 parts, that is the order of the thickness.

The order of the thickness of the oil film would be in [fol. 112] 1/100,000 of an inch. Or in hundred-thousandths of an inch. And this is true of petrolatum, when it is warmed, as well as of transil oil that is being used, the

two oils mentioned in the articles covering the defendant's construction.

Asked whether he knows what pertrolatum is, the witness said: Why, no I do not. Technically, I do not know the precise process of its manufacture. It is a residue, a purified residue obtained in the distillation of petroleum oil. It is much like vaseline in consistency and in its oily quality. I think vaseline is just a trade name for a purified form of petrolatum.

Commercially, transil oil is an oil that is used in transformers. It gets its name, I think, from that use. It is a rather thin, fluid oil, not so thin as kerosene, but quite a fluid oil. Much more fluid at ordinary temperatures than petrolatum.

Asked if there were no yielding to the suction which occurs in a cable of this sort by cooling, if there were no yielding to that suction, would the suction continue to increase in intensity as the cooling continued, the witness said: Yes. The absolute pressure depending upon what the actual amount of air, of the remnant air, that was left in the cable.

R. D. Q. 185. And does the fact that the casing of the joint collapsed under this suction in one of the instances referred to in the Peterson articles indicate to you anything of the extent of the suction which might occur?

A. Of course, one cannot calculate the degree exactly without knowing all about the dimensions of the sleeve, but [fol. 113] it indicates that it was of the order of a good many pounds to the square inch, probably approaching the total of atmospheric pressure, perhaps. Which is 14.7 pounds per square inch. Probably of the order of 26 or 27 inches of mercury.

R. D. Q. 187. In the Peterson articles it is said that the oil in the joint was found to have migrated 30 or 40 feet beyond the joint into the cable. How did he know that this joint oil had migrated so far into the cable?

A. Only by cutting open the cable and examining it.

R. D. Q. 188. Finding a different oil from that which was originally in the cable, I presume?

A. Well, the flow of the fresh oil in a dried cable would show itself rather readily by the state of the impregnation and the moistness of the insulation, even if the joint oil

were the same as the oil with which the cable itself had been impregnated.

R. D. Q. 190. Now, you have said that in the defendant's joints where varnished cambric is used, the oil gets through between the layers of the cambric. Can you say whether the material itself, varnished cambric, is pervious to oil under substantial pressure or suction?

A. Not from having tried it. I know that such materials which will apparently not permit the passage of oil when there is no suction will readily permit it when there is suction on the under side; therefore if a void occurs inside of such wrapping and the pressure gets to be low, relative to the pressure on the outide, then the oil would go through either the paper or varnished cambric.

R. D. Q. 191. Would you think that there is any substan- [fol. 114] tial difference in this respect between the oiled paper which has been used in the older times and the varnished cambric which is used more popularly now and is used by the defendant?

A. I cannot say as to just what the relative pressure that is required to go through a given thickness would be, but it would probably be of the same order.

Mr. Usina: That closes Plaintiff's case, if your Honor please.

Russell K. Glover, a witness on behalf of the defendant, having been duly sworn, testified as follows:

Direct examination.

By Mr. Neave:

I live in Baltimore.

Mr. Neave: I will say, your Honor, that the testimony of this witness relates to a prior use.

I am general foreman of the underground distribution system for the Consolidated Gas, Electric Light and Power Company of Baltimore. I have been employed by that company for 32 years this May. My position with that company

in 1911 and 1912 was General foreman of underground distribution.

My responsibilities with respect to high tension power cables at that time were insulation and maintenance.

[fol. 115] Our power cables were lead sheathed, three conductor cables. Each conductor was insulated with a paper wrapping. Between the intervals of the three-conductors and the lead sheath there was a jute filler.

These cables were placed underground in the ordinary conduit system. Through clay tile ducts.

In 1911 or 1912 I was responsible for the maintenance of high tension cables that were at the sub-stations of the company.

Asked how those cables were terminated in the sub-station, particularly at the McClellan Alley station, the witness said: They were brought up from the Alley in the rear, known as Sharpe Street duct, under an old storehouse, into an areaway behind the sub-station. There was a chasing cut out of the wall, just a sort of slot cut down there through the brick work, and they run up through there, through the window to the wall, to the left or north, and run along the wall there and dropped off at intervals under the floor where they were pot-headed. That pot-head and end bell is the same thing. This pot-head that was at the upper end of the cable, that is the terminus.

Asked about how high was the upper end of the cable from the duct level underground, he said: Oh, those heights would be, ranging anywheres between, I should say, 40 to possibly 60 feet.

The voltage of the current carried by these cables at that time was 13, known as thirteen-two; 13,200 volts.

Q. 19. Can you point to an illustration in this book that [fol. 116] I hand you of the type of pot-head used in 1911 and 1912?

The Court: The witness indicates something there.

Q. 20. Now, you have referred to page 42-A. Which one of the illustrations on that page shows a pot-head?

A. This one (indicating), shows a three-conductor.

Q. 21. The one in the lower left hand marked C?

A. Marked C with the three-conductors coming through and extending beyond the rubber disc.

Mr. Neave: I offer in evidence photostatic copy of page 42-A of this Handbook to which witness referred, which was published in 1906.

(Marked Defendant's Exhibit A in evidence.)

Referring to this illustration that I have just produced, the illustration C on the page shows a sort of bell-shaped thing standing upside down. That is made of spun copper.

Q. 23. What is the internal construction of that pot-head?

A. Do you mean in regards to the conductors and cables?

Q. 24. Yes. What is inside of it?

A. Well, the construction of the job would be to strip back the lead for possibly 2 feet.

Q. 25. Lead from the end of the cable?

A. From the cable.

Q. 26. Yes.

A. Taking off the belt from around the three conductors, back to a distance within about two inches of the lead. [fol. 117] That is the belt encircling the three (indicating)——

Q. 27. Yes.

A. —wiping on the copper bell or pot-head.

Q. 28. Well, wiping it. What do you mean, joining it?

A. Regular plumber's joint, wiped joint.

Q. 29. With lead?

A. With lead—no, not lead. It is 40-60 per cent. 40 per cent tin and 60 per cent lead.

Q. 30. So as to make a tight joint between the lower end of the pot-head?

A. And the lead.

Q. 31. And the lead of the cable?

A. Of the cable.

Q. 32. Yes. Go ahead.

A. Then, the pot-head is put up in a free position in the hanger, and three mica tubes, that is, spun, slipped over each one of the individual conductors, and the rubber disc, —no, before the rubber disc comes the filling or compound, then the rubber disc is slipped down over the top, the rubber disc having three holes about 4 inches apart.

Q. 33. Yes.

A. (Continuing:) And the mica tubes protrude about possibly 3 inches above the top of the rubber disc. Those are the mica tubes shown in Exhibit A.

Q. 35. To the right of the letter C in the illustration you have produced?

A. If there is anything that sticks up there it is the mica tubes. They ought to be there.

Q. 36. There seem to be three sleeves of some kind right opposite that letter C.

A. Those are the mica tubes.

They are used for reinforcing really the insulation at that point where the insulation comes into contact with the [fol. 118] holes in the disc, they were then collected on the top, and a disc put on them, and naturally their going across to the top would form a passage for automatically discharging and going to ground. That rubber disc rested on the top of the pot-head. It did not necessarily hermetically seal the pot-head. That was not made for that purpose. Air could get in or out. The compound flows up there and might possibly seal it up.

The compound with which these pot-heads were filled when they were first installed was paraffin. It was poured in hot. We used to heat that up to approximately 230 degrees, 240. When it got cold is solidified.

Those pot-heads were put in there along about 1904, 1905.

Approximately 50 of these pot-heads were in use in 1911 and 1912 at all the stations that we had in our system.

Asked, were these pot-heads, constructed as he has said and filled with paraffin, satisfactory in use, or did he have some trouble with them, the witness said: Well, to all appearances they were satisfactory as we knew it at that time. They did not prove so later on. It happened that the cables, some of them, at the height that they were set, the pot-head was seen to start to dry out. We had failures: We did not attribute it at first to drying out of the cable; we simply had failures.

Asked how would the failure evidence itself the witness said: Well, a failure in a high tension thirteen two cable, there is not so much immediate evidence but whether somebody drove a nail into it at that point, and outside of the failure, whether they drove the nail, I would not be there, [fol. 119] and that is all; but there was a general explosion of the cable itself, and a number of those things broke off and burned off. Well, as you saw it, it burned out and would take out 18 inches or 2 foot of cable.

Q. 54. Where would these failures happen? How far below the level of the pot-head? That is, would they happen at some particular point at the height of the cable?

A. Not always.

They might happen anywheres. You get some 18 inches back to, oh, 20 or possibly 30 feet from the pot-head. That is 18 inches below the pipe on that bell, not in the pot-head. We had no failures in the pot-head proper. When these failures began to occur I made an examination to determine their cause. First we thought it was just a kind of, probably a mechanical injury and owing to negligence on the part of the mechanic in some way in making short bends and creasing the paper inside—the insulation—but they were coming along too frequently, and we started to delve into the matter to see what was the trouble, and by cutting off the paper of the lead sheath a few feet back we wound that that paper was absolutely dry.

Asked where was it that he opened the cable and found that the insulation was dry, he said: The customary thing when we would take a cable out of that kind, we would not just immediately cut a short piece off and put a joint in; we would draw the cable out, possibly back to the first joint, if there was one in the areaway, and if it extended back around the manhole there, why, we would take it out to that joint. And I found that the cable insulation in that [fol. 129] cable had all dried up. There is no doubt about it; that was the reason for the failure of the cable.

In this illustration that I have produced, on the top of the pot-head the three conductors running up go through insulators and through the walls, and then flow freely up to the bus structure, up into the disconnecting switches.

Q. 65. Now, having experienced a good many of these breakdowns occurring at the pot-heads, and having opened a cable and ascertained, as you supposed, what was the reason for the failure, that it became dry, as you have explained, what then did you do?

A. We were looking for a solution, some method of the discontinuance of this interruption to service; and so I took it up with my superior, Mr. Beyerle, about filling the cable with a suitable compound which would flow.

Q. 67. And then what was done after you took it up?

A. So we decided—there was no known compound at that time which would flow freely enough, so I suggested

that we put in the same compound as the cable was originally saturated with, figuring that if it was good enough for the original manufacturer of the cable it surely ought to be all right to fill the joint with, and let it continue on and saturate.

Q. 68. What did you do next? Did you get some of that same compound or oil that was used for saturating the cables you were using?

A. Yes, we got a 50-gallon drum from the National Cable & Conduit Company, who had supplied the cable. Mr. Edmonston is the general superintendent.

Asked whether Mr. Edmonston had any part in obtain-[fol. 121] ing this oil for this purpose, the witness said: Why, Mr. Beyerle and he talked the matter over, and Mr. Edmonston thought that the idea was very good; so they instructed the purchasing department—I just do not know how—to have the National Cable & Conduit Company ship us a barrel of oil. That oil was not immediately shipped.

I am familiar with Mr. Edmonston's signature.

The witness was shown what purports to be a carbon copy of a letter with Mr. Edmonston's signature on it, and was asked if that was his signature and the witness said: Yes, sir; it is. That particular copy came out of Mr. Edmonston's files in the office.

Mr. Neave: I offer in evidence the letter which the witness has identified.

The Court: You have no objection, have you, Mr. Usina?

Mr. Usina: No.

The Court: No objection.

(Marked Defendant's Exhibit B in evidence.)

Mr. Neave: The letter, your Honor, reads as follows: (Reads Defendant's Exhibit B).

Q. 76. This letter of Mr. Edmonston's to the National Cable & Conduit Company refers to a letter, a copy of a letter, received by your purchasing department from the National Cable & Conduit Company's Philadelphia office. Do you happen to know whether that is a carbon of the letter there referred to (handing to witness)?

A. Yes.

[fol. 122] Mr. Neave: I offer that in evidence.

The Court: Is it necessary to go to all this trouble about this?

Mr. Neave: I want to prove my dates.

The Court: All right.

Mr. Usina: I do not know. This seems to be a typewritten copy, not even on a letterhead. I have not objected to it as not being the original.

The Court: Well, it is mentioned in the other letter, to which you had no objection.

Mr. Neave: I only want to make it consecutive.

Mr. Usina: I withdraw the objection.

(Marked Defendant's Exhibit C in evidence and read by Mr. Neave.)

Mr. Neave: I offer in evidence an original of the letter from the National Cable & Conduit Company, dated May 26, 1911, to Mr. Edmonston of the Consolidated Company of Baltimore.

(Marked Defendant's Exhibit D in evidence and read by Mr. Neave.)

Mr. Neave: I offer in evidence a stipulation to which is attached photostats of the National Conduit & Cable Company's invoice, dated June, 1911, showing the shipment of that material.

(Marked Defendant's Exhibit E in evidence.)

The Witness: I received this material, this oil, that we have been talking about, from the National Cable & Conduit Company.

Asked what did he do with it, the witness said: Why, we [fol. 123] started to get over the route and fill up—remove the compound from the joints, and we fill them with the oil.

The compound in the joints was paraffin mostly. We removed that paraffin or heavy compound if it was there and substituted oil.

We did not have any occasion in 1911 to order cable saturating compound for any purpose other than to refill these cable pot-heads. There was no other use we could use it for.

Asked when he first filled those pot-heads with oil, how much oil did each pot-head hold, how much could he pour in it to fill it, the witness said: Oh, I just think the joint

will take approximately two gallons or a gallon and three quarters, somewheres along there. When we first used this oil in these pot-heads, we filled the pothead up full.

Asked what he found in the operation of the cable the witness stated: Well, we were a little neglectful in going back, and I might say it caught us asleep on the job, in thinking that the amount of oil would not migrate as rapidly as it did. We let them go for over a month, and then some of the bells were found that they were down to probably a half a gallon of oil. That is, the oil had soaked out into the cable. At the start we never filled those pot heads so full that they overflowed in use. We filled them pretty well up to the top, and, as I say, we went back at the inspection more frequently on account of the first time finding that the oil was getting away so fast, but later on that did happen. We had to reduce or fill them up possibly to within about an inch or an inch and a half of the top.

[fol. 124] When we filled them up to the top they used to overflow, due to expansion. That oil that overflowed had to come back from the cable. It was forced up from the cable.

I was here yesterday and heard the witness yesterday talking about the breathing of the cable and the oil coming out of the cable.

Asked if, in his opinion, that is like any breathing, or is it different from the breathing, the witness said: I do not see how a cable can breathe. You might call it breathing. I would call it expanding.

In the use of our pot-heads, when filling them full of oil and the oil came out of the top of the pot head, that was due to expansion. It happened only when the cable was loaded.

When we first filled these pot-heads with oil the oil was taken up very rapidly into the cable and then we had to refill the pot-head. The second time it was filled the oil got away very rapidly. After the second filling, not so rapidly.

After we had gotten two or three fillings of oil in there, after we had gotten the whole thing well saturated we would fill the pot-heads approximately every three or four months, why, we felt safe that we could discontinue the inspection; that is, not as much, not as regular as we had been. Feeling that the cables had taken up pretty nearly

all they were going to take, and it was not necessary to go in every two weeks or so to look them over. But we kept on filling thereafter.

We made inspections, as I said, every two weeks, and then got down to a month, and then two months, and gradually on, we went on to three months, and gradually to six [fol. 125] months. Records were kept of filling the pot heads in this manner. The record of the actual filling was kept in my office.

These cables had to be cut out of service at the time when the pot heads were filled.

I have the station log of the McClellan Alley station for the years 1911 and 1912. It is there in that portfolio or brief case.

Q. 114. There are five large books; what does each of them mean?

The Court: Suppose you step down, Mr. Glover.

Q. 114. (Continuing:) Do these books contain information only with reference to the filling of these pot heads? There are a lot of other things too.

A. No, just the general log of the station pertaining to operation or any injury, such as cutting out and starting our machines, those taken out of service, or anything pertaining to any of the operation while the operation is on. There are the original five books and they contain entries with respect to the filling of these pot heads.

The Court: They are all from your department, are they not?

The Witness: No, these are from the sub stations.

The Court: Oh, sub-stations.

The Witness: I have nothing to do with that outside of a request.

Mr. Neave: These are the log-books of the company?

The Witness: These are the log-books of the company. This is one at the top.

The Court: All right.

[fol. 126] Q. 117. You have pointed to one of these entries on page 101 of one of the books. It seems to be of a date in July or August, 1911. "Glover's men refilled pot-heads on 24 and 25 cable. Disconnected." That is you, is it, Glover?

A. I am Glover.

Mr. Neave: I show plaintiff's counsel these various books, and I offer in evidence photostatic copies of these various entries in the books relating to the filling of pot-heads in those years. Those photostats will be here this afternoon.

The Witness: After we had adopted and put into effect the practice of filling these pot-heads with the oil that we got from the National Cable & Conduit Company, the difficulties that we had previously experienced were entirely overcome. We are still using the pot-heads filled with this oil or similar oil. We have about, probably two dozen still in use, used continuously ever since prior to 1911. Those were the pot-heads which are still up at a great height.

Asked when he put in new cables nowadays, if the cable is to run up to a height above the duct, would he put in a pot-head still, the witness said: We would. We put in a pot-head in any event, whether it is low or high.

Q. 124. And put the oil in?

A. That would depend on the height of the pot-head.

Q. 125. The point I have in mind there is would you use these pot-heads with the oil in them only on old cables or do you use them on new cables also?

A. On new cables too. In 1911 and 1912, we were using [fol. 127] joints in the cables underground, joints in the manholes. And they had a lead sleeve over the joint. That lead sleeve was soldered at each end to the sheath, lead sheath of the cable by a regular wiped plumber's joint. The insulating material which we used inside of the joints in those days, in 1911 and 1912, inside the joint box was paper wrapping. The old construction of the joint was to wrap the individual conductors, and then wrap the entire layer of the exposed conductor from where it cuts off of the belt. In its entirety, from one end to the other. Cut holes through the belt at intervals around that also to allow the free passage of the paraffin or other compound, whichever we were filling with. At that time were filling our joint sleeves with paraffin. And we poured that in by hand along about 240 or 250 degrees at the least. Just the same as in the pot-heads.

In 1911, when we substituted oil for the paraffin in the pot-heads, we did not substitute oil for the paraffin in the joints in the manholes. I spoke to my superior, Mr. Beyerle, about putting the oil in the joint, and he said he

did not see why it was necessary; we were not having trouble with the joints, we were having trouble with the pot-heads.

There were joints in the cables in the manholes near the pot-heads about which I have been talking. Referring to the McClellan Alley station, as I said before, we have some, that we had some joints down in the areaway, which would be about 60 or 70 feet, and some on further; and the next ones along about 125 or 130 feet. That is where the cable had been pulled to go in through that areaway, up through the chasing into the building.

[fol. 128] Asked what is the action on paraffin of cable oil as soon as you fill the pot-heads, the witness said: Why, the oil dissolves the paraffin. I know that the oil which I said migrates from the pot-head along the cable in the course of time reached the joints in the cable because we had occasion to open up and relocate sections of cable in the building, and the minute you would put your chipping knife in them, the oil would squirt out; and then later on, cutting them open, we found they were absolutely full of oil.

The pot-heads that we still have in use even with the new cables, we refill them from time to time with oil. We no longer use paraffin in the joints. We are using compounds known as Ozite and Mineralite. Those compounds do not migrate through the cable.

We are not using any lighter oils on the 13,200-volt cable. In the 13,200-volt cables we have some failures. We also have a 33,000-volt line. On the joint ends of this the filling compound we are using is a lighter oil known as 10 C oil.

We have not had as yet any failures on those joints. We only put them in a year ago, last August.

We have never tried to run our 33,000-volt cables on these joint boxes that were filled with compounds distinguished from the oils.

Cross-examination.

By Mr. Usina:

We are using now on our 30,000-volt lines oil known as a Transil oil, known as 10 C. That is an oil much thinner than petrolatum. Very much thinner than paraffin.

[fol. 129] I said we had some failures on our lines of 13,200 volts.

Asked whether he ascertained the causes of those failures the witness stated: I can only imagine one thing causing a failure in a joint, and that is poor workmanship.

X Q. 175. You mean that whenever your joints had failed you do not have to examine it, you know it has failed because of poor workmanship, is that right?

A. Well, it could be, we could have a failure there due to mechanical injury.

X Q. 174. Yes, but short of that you know there must be poor workmanship if there is no mechanical injury?

A. That is my firm opinion.

Asked how that poor workmanship evidenced itself in the joint when he opened it after a failure the witness stated: Bad sweating of the conductors, not being properly cleaned, fins, improper wrappings of the insulation leaving gaps.

I have sometimes found that the tape insulation when we scrape it off is dry in the spaces between it. In some of these failures, in both the paper and the varnished cambric. But I might say that that insulation was put on dry. On the 13,200 volts we always put on varnished cambric dry on the paper in those days. We never saturate it with oil before we put it on.

X Q. 183. Then you do not know in what particular detail those joints were defective on your 13,200-volt lines when the joint failed?

A. I know pretty well why they were.

X Q. 184. Tell me in detail, please.

A. As I stated before, fins of solder left in the joint, improperly wrapped insulation, either varnished cambric or paper insulation leaving voids in between the wrapping, [fol. 130] and more than anything, improper filling of the compound at an improper temperature.

Asked how this improper filling of the paraffin compound would evidence itself when he opened the casing the witness said: There would be voids in there. Not necessarily air cells; settlement of the compound or the paraffin. You can't fill a joint and solder it up. My experience has been from the time that you fill a joint and complete the soldering up there is a time elapsing in there of between 6 and 7 hours. It is not all finished up in one filling, it takes several, and

proper filling with compound or even paraffin will overcome a multitude of bad workmanship.

Practically the way we fill even with melted paraffin is that, after preparing the casing, we pour in the melted paraffin and then we wait for a while for it to run into the cracks and settle, and then we pour in some more. In the first pouring in we generally run through probably half a gallon. There are two holes, one cut in each end of the sleeve, and we run our paraffin through. One hole is a little lower than the other, that is to wash out moisture and everything of that sort. We let that settle until it becomes solidified, and then put another filling in, and so forth, and that is continuous until the job is finished.

X Q. 192. Referring to the pot-heads in which you put a compound similar to that that is in the cable, how often do you refill those pot-heads nowadays?

A. With paraffin?

X Q. 193. With anything at all. I am asking you with either paraffin or thin oil.

A. Well, once they are filled with paraffin they weren't bothered any more, that job was complete. Those that [fol. 131] were filled with oil were different. The pot-heads that we filled with oil, we still refill those from time to time with oil. As we are going along now, I guess about every four or five months. That is, some of them will take oil, others won't. It might go for six months and not change any in there, but we couldn't guarantee that none of that oil would get away.

X Q. 199. Yes; I am not asking what you guarantee or what you think. What I want to know is your actual practice nowadays?

A. We know we can't let it go.

X Q. 200. You know you can't let it go beyond six months with safety?

A. That is it. Every six months we go through and look at them, and some of them need more or less oil. Some of them do not need any. Those that do need oil on our six months' inspection don't need very much oil.

I have previously stated that we have our horizontal joints in our cable in our McClennan Alley station from 60 to 120 feet away from the upper ends of the cables and we have found in those joints some of the oil which we had put into the pot-head above.

X Q. 207. And taking the cases in which you found that oil in the horizontal joint, how far were those particular horizontal joints from the pot-heads? Were those the 120-foot away joints or were they the 60-foot away?

A. We found oil in our joints that we put in the pot-head three and four sections away.

The Court: How far would that be?

The Witness: A section will average about 400 feet, your Honor.

[fol. 132] The Court: About 1200 feet away?

The Witness: Yes, sir.

X Q. 208. I thought you told Mr. Neave that you found oil in the first joint, but you never found any in the cable beyond that first joint, any of the oil that you put into the pot-head. Am I mistaken about that?

A. You are mistaken.

X Q. 209. What was the cable oil, as you call it, which you put into those pot-heads in 1911 and 1912?

A. We tried to get from the manufacturer of the different cables the same oil as the cable had been impregnated with.

X Q. 210. But you did not know what that oil is: what is the name of it?

A. Well, as a general rule we knew what it was. We knew it was resin oil at that time in the early days.

We are not now using resin oil for filling these same pot-heads.

Asked are you using a different oil now the witness said: We are using the oil—that is, we are using it in cables where they were originally filled with resin oil.

X Q. 213. You are still using the resin oil on cables originally filled with resin oil?

A. On the cables originally filled with resin oil but petrolatum or other oils on different classes of cables that have been installed.

X Q. 214. How do you know that the resin oil that you used in 1911 would dissolve paraffin? Have you seen paraffin dissolved in that resin oil?

A. We knew that the joints were filled with paraffin. We found the joints filled with oil with small portions of paraffin floating around in there, I did not actually see the dissolving take place.

[fol. 133] X Q. 215. There wasn't any other place for the paraffin to go, and there was some of it still left, so what was there originally must have been largely dissolved in the oil?

A. Dissolved in the oil, yes, sir.

I suggested to Mr. Beyerle, W. P. Beyerle, my superintendent, that the horizontal joints should be filled with resin oil or the like.

Asked if he remembered his conversation, his actual words on the subject, the witness said: Yes, I have a very good recollection of it. They did not seem to like my idea at all when I put it before them, and I didn't like at all them resenting it inasmuch as the cable, as I told Mr. Beyerle—I couldn't see his objection. We are very particular about taking a company's cable and putting anything into that which they do not prescribe on paper. We generally try to buy all their own material from the manufacturer. If we buy the cable from the Standard we in all probability would put their material, we would buy their material to put into that joint. There is more or less reason for that. If there is any come-back we haven't departed from their usual rule or their standard of making a joint. Also, my argument with Mr. Beyerle was I couldn't see why, if the cable company were satisfied to put this oil in to impregnate, saturate their paper cable with, why, it isn't good enough to put in a pot-head and let it continue to saturate it.

X Q. 219. Why did Mr. Beyerle and his associates object to putting it in the joints? You said you didn't like their objections, but I would like to know what that particular technical objection was.

[fol. 134] A. There really was no technical objection to the joints other than the amount of failures in joints were practically nothing. We weren't having trouble with our joints, as his argument was, and so why the necessity?

We will always have trouble with the joints, even with the oil-filled joints. We are going to have trouble always with them; they are not infallible.

X Q. 222. Then Mr. Beyerle wasn't entirely correct in saying you weren't having any trouble with your joints, was he?

A. No.

X Q. 223. When have your last installed a pot-head in which you have put a filling of thin oil? I am asking for the date of installation of a pot head.

A. The only location we have pot-heads now filled with oil are the Highlandtown sub-station; at all other locations the pot heads have been put down to almost the duct level.

McClellan Alley has been put down to duct level and this other one is Highlandtown known as Highlandtown. This Highlandtown station, is the only place at which we have the pot heads elevated greatly above the line.

Asked when he put in the Highlandtown station, and when was that built the witness stated: I believe that station went into effect about 1910 or 1911. That is not really our station; that is the Pennsylvania Water Power Company. We have cables coming from there.

When we first built that station the pot-heads were elevated a considerable height over the cables.

X Q. 230. And when did you first put thin oil in the pot heads of this Highlandtown station?

A. That went in along in effect at about the same time we started filling McClellan Alley, and I might say Pratt [fol. 135] Street, Penn Street, and Westport.

X Q. 231. When you put this stuff in the McClellan Alley station you put it in the pot-heads in other stations too?

A. Yes. If we were working from the McClellan Alley station and that transmission line was going or coming from Highlandtown we would get the feeders out at the same time, and attend to both pot-heads to avoid making two shut-downs, one at each station.

There were six stations in which we filled the pot-heads with this thin oil. Our main power plant, which was Westport, Penn Street, McClellan Alley, Highlandtown, Monument Street and Pratt Street. I think that covers it pretty well.

We filled twelve pot-heads with this thin material at McClellan Alley in 1911 or 1912, that is six feeders on the incoming, and we probably had the same amount coming from the bus to the rotaries.

X Q. 239. And in 1911 and 1912, you filled some at Highlandtown too at the same time?

A. I am not just so sure of the date there. Highland town was a later project entirely in the electrical field there.

X Q. 240. I see. And how many

A. I imagine it was around that same time, though.

X Q. 241. You imagine it was around the same time?

A. Yes.

X Q. 242. That is the best of your recollection?

A. Yes.

I would say in the Highlandtown station we filled about 15 or 18 pot heads with this thin oil around 1911 or 1912 [fol. 136] and about the same time we installed some of this thin oil in about twelve or fourteen pot heads at the westport station. At the same time, around 1911 or 1912, we installed this oil in probably about five or six pot heads in the Penn Street station. Around 1911 or 1912 we installed some of this thin oil in probably four or five pot heads in the Monument Street station. In 1911 and 1912 we installed some of this thin oil in about four potheads of the Pratt Street station.

X Q. 252. Did you have enough of the thin oil in this drum of 50 gallons to fill all those pot heads which I figure up to be about 54 pot-heads?

A. That was not all done at one time. That covered over a space of time before we had them all filled up.

X Q. 253. How long a space of time?

A. Oh, I should judge it took us five or six months to get around to all of those. You know; you can't go into a station and say, "We want this cable out." You have to wait until your opportunity comes, and work mornings, nights, and different times.

X Q. 254. I understand. What I want to know is whether you made this 50 gallon drum supply all the thin oil you needed for these 50-odd pot-heads?

A. Oh, no; no, indeed.

X Q. 255. You ordered some more?

A. There would have to be more ordered.

X Q. 256. You would have to get more of the same material?

A. Yes.

X Q. 257. Do you remember getting it yourself, you have a recollection that you got some more drums of that same stuff?

A. I wouldn't have any knowledge of that; that would come into the store room department. When they stock an [fol. 137] article of that kind and it gets low, starts to get down, they would immediately call up the purchasing department and have them replenish the material.

X Q. 258. Well, they wouldn't replenish it without an order to do so, would they?

A. That wouldn't come from me.

X Q. 259. Then you can't say of your own personal knowledge that they ever had more than that first drum of 50 gallons, can you?

A. Oh, yes.

X Q. 260. How do you know that they had more than that?

A. I know, for this reason; we had Standard cables coming along there about that period.

X Q. 261. Yes.

A. And we didn't think it advisable to put another manufacturer's impregnating medium into this man's cable, into another manufacturers' cable, so we ordered the same oil that they impregnated their cable with to fill their cables.

X Q. 262. How do you know that, Mr. Glover? Are you just guessing because you feel sure it must be so, or do you have actual knowledge of it?

A. No, no. That was a part of the argument with Mr. Beyerle and myself.

X Q. 263. Mr. Beyerle told you that they had more of it?

A. No, Mr. Beyerle, when I asked him, "How about filling the Standard cables with this?" he said, "No". He said, "We will have to get the saturating compound from the Standard Company to put in the Standard cables," and we had brass bands around our filling pots marked "Standard" and "National". They were sweated on there.

[fol. 138] X Q. 264. Of these approximately 54 pot-heads that you have said were filled around 1911 or 1912, some of them were Standard cable and some were National Cable, that is, the pot-heads were of National cable in some cases and Standard cable in others?

A. Yes.

X Q. 265. And you had separate drums of impregnating compound, this thin oil, some for National and some Standard cable pot-heads?

A. I believe the Standard shipped theirs in 5-gallon cans; I wouldn't say it was a drum. I know one of the manufacturers did.

X Q. 266. Do you remember seeing such cans yourself?

A. I wouldn't want to say whether it was the Standard or the National; one of them did. After a while the demand wasn't so great, and we got it in smaller quantities.

X Q. 267. Have you no drawings of your actual pot heads? Mr. Neave has shown you a catalog showing a certain type of pot-head, and you have said that that was the type of pot head that you used, but I should like to be more specific and see a drawing of the actual pot-head which you had. Have you no such drawings?

A. We probably have. I know we have blue prints, tracings from which blue prints could be made for you.

X Q. 268. Have you them here?

A. No. It is the same thing, because we have them made at Baltimore now. We are probably infringing on the Standard's rights now.

I spoke of putting a rubber disc over the three cables that project up from the pot head. The purpose of the rubber disc is to keep the three conductors separated. [fol. 139] When they come through the top of the bell or the pot-head, they would come up in this shape (indicating), and they would branch off. Disconnecting switches are placed with barriers in between; they were 12 to 18 inches apart. And they spread out, as they come out this way, they gradually span out in this way, and then it goes through the floor through insulators.

The pot head has a rubber disc over it. It has no other cover except the rubber disc.

The rubber disc is fastened down on it like any other cover; like the cover of a kettle. There is an offset or a step which sets down in the bell. That rubber disc is hard rubber and about a half an inch thick, and I should say a quarter of an inch of it is a step. And it just fits into the top of the pot-head and rests on the edge of the pot-head. Over that we have no additional cover.

Our branches go right up from that rubber cap to the next switch.

X Q. 280. When you wanted to put the filling composed of the thin oil in the pot-heads you just lifted up this rubber cover and poured the oil in under it?

A. No. There is a half inch hole in addition in the top of that cover.

There are three holes for the cables to go through, and then there is a half inch hole besides. That was originally put in for refilling after settlement of the compound, that is, the harder compounds that we used.

In using this harder compound we would assemble the three conductors, put our mica tubes on, slap the rubber disc down over it, and then fill it up. We would fill it with the hot compound up to the top. And then let it settle down [Fol. 140] before it had started to solidify. And then when it settled we would put in some more melted paraffin through this little hole in the rubber disc.

X Q. 288. How often did you have to refill it with paraffin?

A. Why, that was the complete process in the old days.

X Q. 289. The second filling completed it?

A. The second or third, but that was done at the time.

X Q. 290. Done in one day?

A. Done in one day; we never held back to do any refilling.

X Q. 291. Then the pot head, through this opening in the rubber cap, is always open to the external atmosphere, isn't it?

A. In the little hole, we had a plug in, as far as that goes.

X Q. 292. You keep a plug in there?

A. Yes.

X Q. 293. What kind of a plug was that?

A. Just a wooden plug.

X Q. 294. Like a bottle cork might be?

A. Yes.

X Q. 295. Well, atmospheric pressure could go through that little wooden plug, couldn't it, around the edges of the plug?

A. Well, that is a possibility.

X Q. 296. You do not think you have an air-tight closure on this pot-head, do you?

A. Practically so, in one sense of the word. It wouldn't do for a Standard water test, I do not suppose.

X Q. 297. You think water might be forced through it?

A. Oh, yes, it is liable to seep in there. Although our conductors are taped down over the mica and right down to the edge of the rubber disc, we would not rely entirely

upon the insulation of the cap coming through the mica disc. That had to be taken care of and built up properly. [fol. 141] That was due to the fact that we had other insulation there that would spoil at the higher voltage wire that was connected to the disconnector switches.

X Q. 298. I think you said you had about 50 pot heads in 1911, and that most of them had been installed around 1904, and that those had been satisfactory from 1904 to about 1911.

A. Not all of 1904.

X Q. 299. No?

A. Our original installation was six cables from Westport.

X Q. 300. That was in 1904?

A. That was in the latter part of 1904 or '05, some place along in there.

X Q. 301. And they ran satisfactorily until around 1911, did they?

A. No, I wouldn't say so. I do not know just when our troubles started on them, and the failures in the cable. They weren't so numerous because our cables weren't so numerous around that time. Another thing, our load was very light; there was but very little demand on the cables.

X Q. 302. You never found this failure due to dry insulation in the cable risers of only a short height above the conduit, did you?

A. No.

X Q. 303. And yet, where you had a height of 40 feet or thereabouts, as you have testified——

A. No, we had failures on cables that weren't over 12 or 15 feet from the duct level.

X Q. 304. And did you use this expedient of filling the pot-heads with a thin oil on those cables of 12 foot height?

A. Yes.

X Q. 305. Taking the cables that you have testified about, I think you said there were no failures in the first 18 inches below the pot-head.

A. No failure starting from approximately 18 inches below the pot-head; failures starting from that point to a [fol. 142] point back for several feet, sometimes 20 or 30 feet.

X Q. 306. But within the first 18 inches below the pot head you didn't have any failures, that is my understanding of what you said?

A. Yes. We have had failures in between there, but that was generally about the location.

X Q. 307. So you mean some of them occurred within the first 18 inches, and then they occurred all the way down?

A. Yes. I was just giving the approximate location taking, the multitude we had was something about like that.

X Q. 308. When you examined the cables in the pot-head itself in the case of these failures were the cables within the pot-head dry? I mean, was the insulating wrapping around the cables dry within the pot head?

A. Well, that small portion of the cable, we never looked at that much. That is, in getting the bell off it would destroy a whole lot of the evidence, and naturally the cable having burned out, would be dry. Would dry it at that point. It would be thin at that point right immediately around that bell.

Our bell is a spun copper bell, spun from a sheet of copper and is threaded over the ends of the three bare conductors.

In the year 1911 I would say we had more failures in the vertical lengths of cable.

Asked about what proportion the failures in the vertical lengths were compared with the failures in the horizontal lengths, the witness said: We wouldn't have but very few failures in our duct sections at that time.

Asked how the paraffin was removed from the pot-heads in order to put in the thin oil the witness said: Why, the [fol. 143] paraffin was very easily removed. We could take and force the cover up without even disconnecting, inasmuch as we know that if we did distort it a little it wasn't going to affect it. We could take and scoop it out with a scoop or cut through it with a broad-bladed knife; take it out in pieces. Of course, there was some left in there, and we wouldn't bother with that because the hot oil going in there would immediately dissolve it.

We put our thin oil in hot. We did not have to heat our thin oil to pour it in, it would have poured all right, but it made a quicker job, and the heating of the oil at that time

was to help dissolve the paraffin, things like that, which might temporarily act as a dam down there. We didn't want to go down and fish around in the crotch and destroy the insulation, because that is the vital point right in here between the three conductors. It was more for that than anything else.

This oil would flow at ordinary room temperature quite freely. Not as freely as water. Nowheres near so.

X Q. 320. But after you heat it up to perhaps the point of boiling water, something like that, it would flow very easily?

A. It wouldn't take so much heat to heat it up, that is, to make it quite fluid.

X Q. 321. After you had done heating it and filling the pot with it, did it harden in the pot, or get to such a consisteney that it would not flow?

A. No, not in the summertime. In cold weather it was right stiff, about the consistency, I should say, of a light grade molasses.

I should judge we have now 150 pot-heads in our system. [fol. 144] In our distribution system we are now filling 22 or 24 pot-heads with thin oil. The number is right in that book there, and can be seen. There are about 126, approximately, which we are not filling with thin oil.

X Q. 329. Now, are these 126 all on risers which are a comparatively short distance above the duct system?

A. A great many of those cables today are actually lower than the duct system.

X Q. 330. Of them all, to the best of your recollection, which pot-head is highest above the duct system of the 126 which you are not filling with thin oil, which of them is the highest above the duct system?

A. Today I would say the highest one would range along between 35 and 40 feet.

X Q. 331. Which you are not filling?

A. No, that we are filling.

X Q. 332. But of those which you are not filling?

A. Oh, the height.

X Q. 333. Which is the highest?

A. Why, we probably have some about 10 or 12 feet.

X Q. 334. And those get along without a filling of thin oil?

A. Yes; that is a later type cable.

X Q. 335. You haven't had any difficulty with the cables drying out?

A. No.

X Q. 336. Where are those located?

A. Those are located at the Highlandtown sub-station.

X Q. 337. Isn't it the practice of your company to spread information of any new developments through the National Electric Light Association, and the Edison Electric Illuminating Companies Association?

A. There is a questionnaire that comes around and we answer questions that are asked through that department.

X Q. 338. Doesn't your company have a man on the committees of one or another of those associations which are [fol. 145] devoted to news of new developments?

A. We have two or three.

X Q. 339. Can you tell me which officers of your company are deputized to these associations?

A. I believe Mr. Ricketts, Mr. Forrest Ricketts, and L. G. Smith. Those are the only two that I could name. I am pretty sure they are.

X Q. 340. This scheme of yours to replenish certain potheads with a thin oil you regarded as a thing of importance, did you not?

A. As far as we were concerned.

X Q. 341. And did you make any effort to spread the good news through the National Electric Light Association or the Association of Edison Electric Illuminating Companies?

A. Not I personally.

X Q. 342. Do you know whether anyone in your company did so?

A. I do not.

X Q. 343. Did you keep it secret?

A. No; the question was asked, in fact, I vountarily went to the United Railways of Baltimore, to the man in a similar position to mine, and told him what we were doing to eliminate troubles of this kind.

X Q. 344. He might have had troubles of the same sort?

A. Their cables are all lower, they weren't suffering from it. That is the only other company——

X Q. 345. Who was this man to whom you told the story?

A. Mr. Moat.

X Q. 346. How do you spell that?

A. M-o-a-t.

X Q. 347. Of what company?

A. United Railways.

X Q. 348. That is the street railway company in Baltimore?

A. Yes. I made no special call on him; I just casually met him on the job around the street some place.

[fol. 146] X Q. 349. When did you tell him about it, as far as you can recollect?

A. I told him of the trouble that we were having. We generally get together on those things, and we were paralleling the same line; and when we have a burn-out or anything like that, we both usually get on the job to see if he has hurt our cables or if I have hurt his cables, so to speak.

X Q. 350. To see whose ox is gored?

A. That is it. And after it is burned out we generally take the papers and tear them up and let it go at that.

X Q. 351. About when, as nearly as you can recollect it, did you tell this story to Mr. Moat?

A. I couldn't just specify the particular time; it was around that period that I met him.

X Q. 352. Around 1911 or 1912, you mean?

A. Yes—no, no, sir, it wasn't Moat. Moat wasn't there at that time. Mr. Potes, he is not with the company any more; he is in Baltimore, though, if you want to verify the statement. Joseph is his first name.

X Q. 353. Is Mr. Potes connected with any electrical company now?

A. Not now; he is in the insurance business now.

X Q. 354. Did you ever tell Mr. Moat about it, as far as you can recollect?

A. Mr. Moat at that time was splicing, and I might have told him; in fact, any of the boys.

X Q. 355. He wasn't foreman at that time, he has later been made foreman, is that right?

A. Well, he was sort of a foreman, but now he is the general foreman and splicer. They do not have such a big crew down there, and sometimes a fellow will be foreman on one day and the next day be a mechanic.

[fol. 147] X Q. 356. It seems to me, Mr. Glover, that your recollection about telling people about it is rather vague, isn't that so?

A. Only in the matter of fact, as I say, that things like that pertaining to our underground work, why, we have a great deal in common in electrolysis and electrolytic action.

X Q. 357. You think you probably told either Potes or Moat, but you are not sure of it, are you?

A. I am pretty sure that I told them, because a thing like that, I do not think we would let get away. It appeared to be of too much importance in the operation of cables.

X Q. 359. Do you know any other company which has used the same scheme prior to, we will say, 1915?

A. Only by hearsay; I know of one happening. It wasn't really a lighting company; I was talking to a representative of the Standard Company, that is a good many years back. In fact, I think it was up along the time they were in town here installing cables for us about that period, that they said they had trouble up in Canada, where they had quite a high grade that their cable went up, and they were having trouble with the drying of the cable at the top, and whether he told me that they put oil at the top and put a tank at the bottom, something like that, or vice versa, I do not just remember.

I wouldn't want to say when I did have this conversation with the Standard man. They were in town several years, consecutive years, installing cable, and I wouldn't say as to that offhand.

The Court: Was it before 1915?

The Witness: Yes, I believe it was.

The Court: I mean you are sure it was before 1915?

[fol. 148] The Witness: I was just trying to recall some facts that would establish the date. I wouldn't want to say, your Honor.

X Q. 362. When you filled these pot-heads where did the oil go that was in there the next time you inspected it?

A. Why, there is no doubt that it ran into the cable.

Asked what was the construction of the cable at the foot of the drop from the pot-head, the witness said: Well, as I said before, there was some of the locations that we had joints quite close, and others were some distance away.

X Q. 364. But I mean this riser of the cable ran down, and at its lower end was it simply bent in the lead-covered cable, or was there a connection of some sort, and what connection was there at the bottom?

A. Simply coming down the wall and bending, and going on in a pipe. There was a bend here if there was an airy-way, and if there wasn't, it was in the vault. At the joints on the horizontal there was no bend in the corner.

X Q. 366. Do you know where the original oil in these riser cables went in order that you should find them dried out?

A. Well, that is not so hard to answer. A cable that is wound on a drum in the factory, it has what you might say, an initial set in its coil. When you take and reverse this coil and put it down and pull it out, your lead is expanded. I do not know whether it is proper to say expanded or distorted, because there is no heat or anything like that to expand it; and you have joints through your cable——

X Q. 367. Yes.

A. You cannot get away from it; in any cable that is put on a coil you have——

[fol. 149] The Court: In the manner of unwinding it——

The Witness: In unwinding it, the lead loosens up.

X Q. 368. And you think that accounts for all the loss of compound in these risers of 40 or 60 feet which you found dry?

A. No, I do not say in 40 or 60 feet; we found the oil three or four sections back in the cable; sections of the cable——

The Court: 1,000 feet?

The Witness: Yes, they would average, you can take an average of about 400 feet to a section of cable. Your Honor, one section may be only 150 feet, and the next one may be 550 or 600 feet.

X Q. 369. I think you misunderstood me. You are telling me where the oil went, but I am asking you about the condition of this cable before you put this oil in. You said the riser was dry from 18 feet down to perhaps 40 feet.

The Court: 18 feet?

X Q. 370. 18 inches down to perhaps 40 feet originally. It was full of the compound or oil through that 40-foot length. Now, where did it all go in order that you should

find that stuff dry? Do you think that went into the spaces made by the straightening of the coils of the cable?

A. When you say "full of oil", that does not mean much. There is very little oil. Most of the construction of the cable is insulation. The oil is simply put in there as a filler. [fol. 150] You could take that sample of cable right over there now, and take it off of the end and you will find very little oil there. There is not a great quantity of oil in a paper cable.

X Q. 371. So you think it all went into the voids that were caused by the straightening out of the coil of cable?

A. Very little, very little expanding or distorting of the cable. Lead itself would take up oil.

X Q. 372. This oil that was in the riser of the cable originally ran down and then that could get into the first horizontal joint; it would dissolve the paraffin in that joint, would it? I mean the cable as originally installed, not after you put some oil in it, but before that.

A. No.

X Q. 373. It hadn't dissolved any of the paraffin?

A. Oh, you would find it in something of a plastic form. You would find it where the oil had attacked it. You would find that in any joint, even if it hadn't been filled with oil. You would find it a mile away in a joint where there was a low grade, and the oil had migrated both ways from the end of the joint. You could see where it had started to attack the paraffin and dissolve it, so to speak. It looks more like the man had never put any paraffin in that end at all, though you would find it in the oil.

I said in one case when we stuck a knife into a joint sleeve the oil spurted from it. That was a horizontal joint. It had become filled with oil. I do not know how much spurted out. There wasn't such a great quantity spurted out.

X Q. 378. A cupful or a drop of it?

A. There was a whole lot run out, a great quantity of it run out, which showed that there was a pressure there. [fol. 151] X Q. 379. Yes, showing that the oil was under pressure to run out?

A. Yes.

X Q. 380. Do you suppose when this oil you have kept filling in these pot-heads runs down and fills the riser and runs clear back into the horizontal cable, does it expand the lead covering of the cable, or how does it get in there?

A. I can't say that it expands the ordinary lead cover of the cable. We have found joints which had been expanded due to oil pressure; I do not know that we ever did—and we found them on the ends of long grades that probably had two ~~one~~ three sections, and on cables, which were heavily loaded, where the heat had lent a great deal to the expansion.

X Q. 381. Did you ever find any of these joint casings expanded very near to a riser with a pot-head in which you had put in a filling of oil?

A. No, I can't remember any at that point.

X Q. 382. In these cases where you found the risers were dry are you certain that there was no break or leak lower down in the cable?

A. No; that would have been very evident.

X Q. 383. There wasn't any way in which the oil could have run out of the cable?

A. We had one such condition which showed.

X Q. 384. Where was that?

A. At the Highlandtown sub-station we had oil running out of a duct. I thought possibly first it was the grease or oil with which the cable was swabbed when it was installed. And we had it cleaned up. It was all mixed with this oil so that it was hard to tell whether it was resin oil or not. After we cleaned it up, after we cleaned up the oil or grease and went back there the next day, we found that it was [fol. 152] resin oil. It was very easy to tell. So we pulled the cable out and found out that there was a mechanical injury.

X Q. 385. That is the only one instance you know of?

A. That is the only one instance I know of.

Mr. Usina: That is all.

Redirect examination.

By Mr. Neave:

R. D. Q. 386. Did you yourself fill these pot-heads with oil? Did you do the work yourself?

A. No, sir.

R. D. Q. 387. At times?

A. No.

R. D. Q. 388. Did you ever see the receptacles, the barrels, and so forth, in which the oil came?

A. Yes.

R. D. Q. 389. Did you ever see more than one barrel of oil?

A. That was kept in our oil house; there were several barrels of all kinds of material there.

R. D. Q. 390. I mean did you ever see more than one barrel of the oil that was used in filling these pot-heads?

A. I couldn't say that I did. We only had one tapped at a time, and that is all I would be interested in, unless we had, during the first period, of course, we had two barrels, one of Standard and one of National.

R. D. Q. 391. You say you only had one tapped at a time, that was all you would be interested in?

A. Yes.

R. D. Q. 392. Why would you be interested in that one tapped at a time?

A. Why, we were using it from time to time, and we had to have it opened or accessible.

R. D. Q. 393. What do you mean by "tapping", do you mean a spigot or something protruding out of the barrel? [fol. 153] A. A spigot extending from the barrel.

R. D. Q. 394. Do you know of any barrel that ever went empty of oil that was used in filling these pot-heads?

A. No.

R. D. Q. 395. Was there a supply of this oil on hand at all times?

A. Kept continuously.

R. D. Q. 396. From 1911 on?

A. Yes, sir.

There are about 200—250 of horizontal joints, for the 33,000-volt cables that have the oil in them yet. We still have thousands of joints that haven't got oil in them but have the heavier nonmigrating compound.

R. D. Q. 399. Let us think for a moment about those joints that you have that are filled with oil. This oil when cold, will it run, can you pour it easily out?

A. The saturating, the oil——

R. D. Q. 400. The oil that you use in the joint boxes in which you do use oil.

A. In moderate weather like this it flows quite freely. As I said, it has the consistency of about molasses, something like that.

R. D. Q. 401. You could pour it easily, couldn't you?

A. Oh, yes.

R. D. Q. 402. When that light oil is put into the junction boxes is it put in hot or cold?

A. We always put it in hot.

R. D. Q. 403. Why?

A. We were sure of leaving some compound——

The Court: You mean paraffin?

The Witness: Or paraffin in the pot-head.

R. D. Q. 404. I am not talking about the pot-head, I am talking about your horizontal joints. When you are filling [fol. 154] the horizontal joints with this light oil do you heat the oil before you put it in?

A. You are talking of the 33 k. v.?

R. D. Q. 405. Yes.

A. We boil out after the joint has been completed.

R. D. Q. 406. I do not know what that means. Do you put the oil in hot or cold?

A. The first filling goes in there hot.

R. D. Q. 407. Why do you heat it before putting it in?

A. Most of that is put through there to wash out the moisture.

R. D. Q. 408. That is, whatever moisture there may be, either in the oil or in the joint?

A. That has located in the joint, I mean.

R. D. Q. 409. So you want a hot fluid to go in there to get the moisture out?

A. To take the moisture out, yes.

R. D. Q. 410. You do not heat it to make it thin enough to run?

A. No.

R. D. Q. 411. That is the ordinary practice, isn't it, in filling a joint, irrespective of how fluid the oil may be, you always put the stuff in hot, don't you?

A. Yes, sir, always.

Mr. Neave: That is all, Mr. Glover.

Recross-examination.

By Mr. Usina:

I do not know that I can give you the exact date when we first installed horizontal joints with this thin oil. We completed a job a year ago last August, just a little over a year ago.

R. X Q. 415. What is the name of the oil that you used in those joints?

A. We have two grades.

R. X Q. 416. What are the names of the two oils then?

A. 10 C is the lighter grade. The other has another num-[fol. 155] ber. It is made by the General Electric Company, or furnished by them.

R. X Q. 417. They are both Transil oils?

A. No, it is not Transil oil. We know that as No. 209 or 219, something like that, or 299. That is a heavier oil.

R. X Q. 418. Is that thin enough to flow at ordinary temperatures?

A. Yes.

R. X Q. 419. Both are thin enough to do that?

A. That heavy oil I might say was used on grades where we couldn't hold the 10C oil up there.

R. X Q. 420. So you put the thicker oil on grades?

A. We put the thicker oil on grades, we had a drop of about 30 feet there.

R. X Q. 421. You didn't want the oil to pass through the cable?

A. That is it.

Met pursuant to adjournment at 2 P. M.; present as before.

Mr. Neave: If your Honor please, Mr. Usina has agreed that we may withdraw the original letters that have been marked B, C and D, and substitute photostatic copies in their place.

The Court: That is all right.

George M. Lyons, called as a witness on behalf of the defendant, having been duly sworn, testified as follows:

Direct examination.

By Mr. Neave:

I live in Baltimore. I am assistant general foreman of [fol. 156] the Underground Distribution for the Consolidated Gas Electric Light & Power Company of Baltimore. I have been employed by that Company for 25 years. My position with the Company in 1911 and 1912 was a cable

splicer. I made the splices in the cables at the joints and pot-heads in the box.

I was in court this morning when Mr. Glover testified. I heard him describe the use of pot-heads in 1911 and 1912 and subsequently. I remember that they were originally filled with paraffin and then the paraffin was later taken out and thin oil put in. I heard his testimony about the oil getting through from the pot-head to the joint box.

Q. 13. Does what he testified to this morning about these pot-heads and joint boxes and the filling of them, and so forth, accord with your knowledge of the situation?

A. Are you speaking now of junction boxes? Do you mean splices?

Q. 14. I mean really the joint boxes of the underground cables in the manholes.

A. These cables—you are talking about the pot-heads that run—these cables that have pot-heads on the end that run through the manholes at the other end, and that have splices on them.

Q. 15. Did you ever have anything to do with making up the joints that exist in the joint box in the manholes between cables?

A. Yes, sir.

Q. 16. What were the other splices you were talking about?

I was thinking of those as splices.

A. You were talking about joint boxes and calling them splices.

Q. 17. I see.

A. A junction box is, to my idea,—what I mean by junction box is a little different from a splice.

[fol. 157] I worked also on the connection in the joint box as well as on the splices. I worked on pot-heads. His testimony as to the use of the pot-heads, and the use of the oil in the pot-heads in 1911 was right.

Q. 22. And did you have any experience there in 1911 and 1912 that showed how he described that the oil got from the pot-heads down through the cable into the joint box?

A. Yes, sir.

Q. 23. And ate out the paraffin there?

A. Yes, sir.

Q. 24. Did you yourself at any time pour oil into these pot-heads?

A. Yes, sir.

Q. 25. There is in evidence here what has been referred to, and will be in evidence, the McClellan Alley sub-station log-books. Under date of September 18, 1912, there is this item:

"Mr. Lyons of the Underground Department examined pot-heads of Nos. 1, 2, 3, 5, 21, 22, 23, 24, 25 and 26 cables and put oil in where needed."

And there is an entry under date of November 15, 1912, as follows:

"Mr. Lyons of the Underground Department filling H. T. cable pot-heads in station."

Was there any Mr. Lyons other than you who was connected with the Underground Department at that time?

A. No, sir.

Q. 26. So these entries refer to you?

A. They must.

Q. 27. Now, it was testified this morning that when you [fol. 158] first filled up, when you first put oil into the pot-heads after removal of the paraffin, the oil seemed to go down very rapidly in the cable, and then the pot-head was filled again perhaps a third time and then it went down much more slowly after that; and after that substitution, if I may call it that, took place, you filled the pot-heads from time to time, did you?

A. Yes, sir.

We filled them full at first, but the pot-heads seemed, if they were heated up, they expanded and ran over, and the oil ran all down on the station floor. It made a terrible mess. So we instructed the men not to fill them so full. We filled them to within about an inch and a half of the top, to allow space for their expansion,—expansion of the oil.

Q. 30. Did you at that time understand or appreciate where that oil came from that came up into the pot and ran over on the floor?

A. It was put in the cable, and ran over on the floor, so it must have come out of the cable.

At the time it came out and overflowed the cable was under load.

Q. 33. When you yourself poured oil into the pot-heads, where did you get that oil from; that is, did you go to some barrel or tank somewheres and get it, or was it brought to you by somebody else?

A. We had oil in the barrels at the Monument Street station, the store room there, an oil house there.

When we wanted oil we went there to get it.

Q. 35. This oil that you put into the pot-heads here, were there always barrels of oil in the station there which you could get?

A. Yes.

Q. 36. Some oil there whenever you needed it?

A. Yes, sir.

[fol. 159] Q. 37. From 1911 to when?

A. To now.

We are still filling pot-heads. We still have oil barrels in our store room, only in a different store room now than what we had at the time.

For all the cable supplied by the National Cable & Conduit Company we use National Conduit Company oil, or oil supplied by them. The oil we use is replenished from time to time when we found a barrel that was empty, the next time we got there, there was another barrel.

Cross-examination.

By Mr. Usina:

X Q. 43. Did you ever find a barrel empty when you went to the store house?

A. I have helped to take down an empty barrel and put up a full barrel.

X Q. 44. Did the very first filling of oil which you made in the pot-heads overflow?

A. The very first filling of oil that I put in the pot-heads, did it overflow?

X Q. 45. Yes.

A. Not right away, not immediately.

But we found it had overflowed when we would return. It had leaked down on the floor. When we went to put in the second filling we found that the first one had overflowed.

Asked how deep is the oil space in the pot-heads, the witness said: Well, this pot-head, I suppose, has a depth of about 10 or 12 inches, the pot-head itself.

Asked how many pot-heads have you now which you fill with thin oil from time to time, the witness said: Possibly, I would say, I would think it was about 50.

[fol. 160] X Q. 50. I understood Mr. Glover to say about 22 or 24.

A. That is to fill at the present time?

X Q. 51. Yes.

A. With oil?

X Q. 52. Yes.

A. About, I would say about 20. About 50 pot-heads altogether.

We have about 50 pot-heads altogether and about 22 or 24 that we fill with oil.

X Q. 54. I thought he said that you had altogether about 150 pot-heads. Does that not correspond with your recollection?

A. 150?

X Q. 55. Yes.

A. I presume if you start to count them up it would be that.

The Court: Are you distinguishing between pot-heads filled with paraffin and pot-heads filled with oil?

The Witness: We don't have any pot-heads filled with paraffin.

The Court: That is it. I understood Mr. Glover the same as Mr. Usina, that he had altogether in the neighborhood of 150 pot-heads; is that right?

The Witness: About 150 pot-heads, yes, sir. And of that 150 pot-heads we have about 22 or 24 that we fill now with thin oil from time to time. We have 20, about 24 pot-heads filled with oil, and the rest of our pot-heads are filled with compound. The compound is either Ozite or Mineralite.

X Q. 61. That is a dense compound; that is not liquid?

A. Yes, it remains about gummy all the time.

In 1911 and 1912, when we first commenced to use this thin oil, I was in the capacity of a splicer then, and I did [fol. 161] not have knowledge of exactly how many pot-heads we did have at that time.

I can only tell you now from the amount of pot-heads that I judged that we had after working in my capacity as foreman.

X Q. 63. Well, now, I do not want that. Tell me how many pot-heads you filled with thin oil around 1911 and 1912 when you first tried this practice.

A. I don't know whether it was in the neighborhood of 40 or 50. Something like that anyhow. That is an approximate figure.

These 40 or 50 pot-heads that we filled were in the Highlandtown, Westport, at Penn Street, McClellan Alley, Monument Street, and Pratt Street stations.

X Q. 66. Did you see the happening that Mr. Glover testified to of the oil spurting out of one of the joint casings when he stuck a knife in it?

A. I had an occasion to have it happen to me when I was a splicer.

X Q. 67. I understand.

A. Yes.

X Q. 68. That was in one of the older joints?

A. Yes, sir.

X Q. 69. That was a joint that had not had oil put into it?

A. No, sir.

X Q. 70. Was that very near the riser with a pot-head on it that you had filled with oil?

A. Yes, it was, I would say about approximately from 50 to 75 feet away from the pot-head.

This particular joint I have referred to was the first joint after you came down from the pot-head.

X Q. 72. And how much of the oil spurted out, was it just a drop or was it a cupful?

[fol. 162] A. No, it ran out. It was about a cupful that spurted out, and then it continued to flow slowly afterward. These pot-heads are covered with a rubber disc.

Asked how he got the oil into the pot-head and did he take up the rubber disc, the witness said: When we first removed the paraffin from the pot-head to put the oil in, the rubber disc was just lifted up, and the pot-head filled up almost full, and the disc put back in place; and then, of course we refilled it in the small hole on top of the disc. Small hole in the rubber disc. The winding on the cable ends in this pot-head were of paper tape. In fact, the windings on the pot-head, we did not have to put any windings on the pot-heads. The paper was brought right out, and the mica tube slipped over the paper. The insulation

was already on there. Hand-wrapping was not necessary.

X Q. 78. Put on the cables in the pot-head or after they came out of the pot-head?

A. It was not. They were not necessary. The mica tube is slipped over that paper insulation, and takes the place of that. There was no joint of one conductor end to another inside of the pot-heads.

X Q. 80. Where was the nearest joint? Nearest to the pot-head.

A. Well, I suppose the nearest joint was the joint after the wires leave the pot-head where they were spliced going to the structure oil switch.

X Q. 81. That would be about half way above the pot-head?

A. Oh, possibly from 5 to 10 feet, I suppose.

After we commenced putting this thin oil in our pot [fol. 163] heads, failures in the risers in which we put that thin oil stopped.

Before we put the thin oil in there I do remember that we did have failures in those uprights. I worked on many a one, all the time in a very hot, uncomfortable place. These pot-heads were inside the building.

Up in the top of the building it was quite hot. Up in the top of the machine room. And it was up in the top that these pot-heads were located.

When we observed these failures and had the cable opened, we found that the cable around the conductors was very dry.

Asked whether he remembered many such failures before he put in thin oil, the witness said: They were quite frequent. I could not tell you the exact amount of them, but they were very frequent.

Asked how he got the paraffin out of the pot-heads in order to put the oil in, the witness said: Well, the paraffin could be dug out with a knife or some sort of sharp instrument, like a putty knife, or something like that. It could be easily dug out. We did it That is how we did it.

Asked what was the last occasion that he can recall in which he has known one of these pot-heads to have been filled with oil, the witness said: In 1931, as near as I can remember it, we refilled some pot-heads at Highlandtown.

X Q. 97. Do you recall Mr. Glover ever having suggested that this idea of thin oil filling should be applied to joints?

A. I could not answer that question because at that time I was working in the capacity as a mechanic, therefore, would not have knowledge of questions of that kind.

[fol. 164] X Q. 98. I am only asking you if you remember.

A. No.

X Q. 99. His ever suggesting it?

A. No.

X Q. 100. You do not?

A. No.

X Q. 101. Did you ever observe in the joint of these upright cables that ran dry any leakage outside of the lead sheath?

A. The only one I can recall right now is the one that Mr. Glover referred to in his testimony this morning. I happened to be the man on the job that did that work. I cannot recall right now ever seeing any other evidence of leakage.

X Q. 103. I am just trying to find out where that oil went that left the upright dry. Can you tell me where you think it went?

A. I can tell you where it is possible that some of it might go. I know oil has come through pot-heads themselves and ran out of the pot head at a lower point. I know that to be a fact.

Oil ran out of one pot-head in the other end of the line. That thing occurs right in our sub-stations today, and on cables that are not necessarily filled with oil. The oil in the cable itself will drain out, and force its way out. Small quantities of it now, not a large quantity. Small quantities of it will force its way out into a pot head at another place. A station at a lower level. The pot heads will have the oil coming out of them. And a different station at the upper level will have a small quantity of oil running down through the cable and leaving the pot-head dry. That is not anything that would be alarming there. I can't say just when I first noticed that. Approximately a few years ago. I can't say that it was not as early as 1915. I can't remember having noticed it as long ago as that.

[fol. 165] HARRY R. WOODROW, called as a witness on behalf of the defendant, having been duly sworn, testified as follows:

Direct examination.

By Mr. Neave:

Mr. Neave: Your Honor, this testimony will relate largely to information, as shown by the records, that Mr. Torchio had at a time that he was supposed to make his invention. It will relate to a few other things, but that will be the principal thing.

I live here in Brooklyn. I am vice-president of the Brooklyn Edison Company, in charge of electrical operation. I have been with the Brooklyn Edison Company since 1922. I am familiar with the various types of joints that the Brooklyn Edison Company uses in its high tension cables.

Q. 6. And what would be the voltages that the Brooklyn Edison Company uses in those cables, between what limits?

A. Between 120 volts up to 27,000 volts on the 60-cycle system, and up to 33,000 volts on the 25-cycle.

There are no circuits at 13,000 volts today. There are some at 6,600 volts, and a number at 4,000 volts.

I am familiar with the joints that are used in these cables.

I was in court yesterday when Mr. Waterman testified with reference to the Brooklyn Edison Company's joints that were described in that Peterson article. That is not [fol. 166] the type of joint that is used throughout our system. That is not the principal type of joint that is used throughout our system at the present time.

The model that we have over here on the table is the type used on the 27,000 and 33,000-volt systems.

Q. 15. For how long have you been using this other type which I have designated as the model?

A. About three years.

Mr. Usina: If your Honor please, I shall ask the purpose of this testimony. If it is something else that the defendant uses, the defendant has agreed that it does use the thing which the plaintiff has shown to be the infringement. I do not know why we should be called upon to consider a lot of other things they use.

The Court: As I understand it, the defendant's device was illustrated in 23 and 24 of the drawings here as enlarged drawings.

Mr. Usina: Yes.

The Court: And that under a stipulation, of the alleged infringing article he admits that they are still——

Mr. Usina: Using that to some extent, I understand, but that they are also using something else. I do not see the purpose of dragging the something else in also.

Mr. Neave: The stipulation was not quite that, your Honor. They asked in their interrogatories as to whether joints were being used by the Brooklyn Edison Company, [fol. 167] as shown in this article, and we replied, "Yes," that some of them were. Then the question was what other types of joints we are using, and we say we are using multitudinous types of joints, but if you will specify what particular type you want knowledge about, we will give it to you. They never asked us anything else. Most of our joints are of this type over here.

The Court: I will say that unless it is alleged that some other issues are raised, why, what I was concerned with was whether you were actually infringing this patent or not, and that there was no necessity for me to listen to testimony as to some device or arrangement that the plaintiff does not complain of in this suit.

Mr. Neave: The plaintiff has given us no indication of what he complains of.

The Court: Well, I mean in this suit. The complaint — the prima facie case is made as to defendant's structure in 23 and 24, as illustrated by the drawings 23 and 24.

Mr. Usina: That is all.

The Court: And that is what I shall hold him to.

Mr. Neave: Very well. My feeling about it is this, and that is the reason I asked the question——

The Court: I understand.

Mr. Neave: (Continuing:) —the number of joints that we have of the type Mr. Usina talked about is small in comparison with the number of joints of the type we have over [fol. 168] here; and while we are trying this case it seemed to me that we might as well get the whole thing that the defendant is using.

The Court: Well, I do not like to anticipate future suits under some other device where the plaintiff does not want to widen the scope of his invention.

Mr. Usina: Plaintiff is not prepared at the present time to answer concerning all these things.

The Court: Very well.

Mr. Usina: Because we have not known anything about it until this minute.

Mr. Neave: I do not want to be in the position of keeping back information from the Court.

The Court: Well, under the circumstances I think that this is immaterial.

Mr. Neave: Very well, sir.

The Court: And irrelevant.

Mr. Neave: I do not want to be accused of not being willing to say what we are doing.

The Court: Yes.

The Witness: Before I came to the Brooklyn Edison Company, I was connected with the Westinghouse Electric & Manufacturing Company. And before that with Stone & Webster. And before that with New York Edison. I was with the New York Edison Company from 1911 to 1920. I took my Bachelor of Arts at Drake University in 1909, and Master of Science in the University of Illinois in 1911. My study had been very largely in the line of physics.

[fol. 169] In 1914, I was assistant to the chief electrical engineer of the New York Edison Company.

Mr. Torchio, the patentee of the patent in suit was the chief electrical engineer.

I was there in a position to know the work that Torchio was doing and the investigations that were being made on joints and cables. I was familiar with the reports that were made and the correspondence that went on in connection with that investigation. I was very intimately in touch with Mr. Torchio about it from time to time.

Mr. Neave: I shall refer now from time to time to correspondence, and I am handing the original of the correspondence to plaintiff's counsel, together with photostatic copies, and I will put in evidence the photostatic copies unless from time to time the plaintiff's counsel may wish something else put in evidence.

The Court: Yes.

The witness was shown a letter apparently signed by Frank W. Smith of the United Electric Light & Power Company, addressed to Mr. Torchio, dated July 7, 1914,

and stated: I know Mr. Smith's signature, and that is Mr. Smith's signature on that letter written at the top of that letter in handwriting is "File report on joints and high tension cables." The "File" is in Mr. Torchio's handwriting; and the other is in Mr. Noe's handwriting. That letter came to my attention at that time.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit F in evidence.)

[fol. 170] Mr. Neave: Your Honor, the first few letters are just leading up to the dates of some reports.

This letter of July 7, 1914, to Mr. Torchio, was as follows: (Reading Defendant's Exhibit F).

The Court: Signed by whom?

Mr. Neave: Signed by Smith of the United Electric Light & Power Company.

Q. 33. This letter of Mr. Smith's, Mr. Woodrow, acknowledges receipt from Torchio of information collected by him while abroad. Were you familiar at that time with the fact that Torchio went abroad?

A. I was.

Q. 34. Were you familiar at that time with the report that Mr. Torchio made upon his return?

A. Yes, sir.

Q. 35. Is this the report (handing to the witness)?

A. Yes, sir.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit G in evidence.)

Mr. Neave: Your Honor, this report of Torchio's reports his visit abroad and what he had learned in Germany, and there are a number of things of interest, but I will read you only one thing now to show that in 1914 (reading Defendant's Exhibit G). So that was something he learned in Germany.

Q. 36. I have here what appears to be a letter from Mr. Cole of the Edison Illuminating Company of Boston to Mr. Torchio, dated July 17, 1914. Do you know Mr. Cole?

A. I do.

[fol. 171] Q. 37. Are you familiar with his signature?

A. Yes.

Q. 38. Is that his signature on that letter?

Mr. Usina: I object to this, your Honor. It is entirely secondary evidence. I do not think the present witness is capable of identifying these signatures in the absence of—Mr. Cole or the sender of the letter.

The Court: I was waiting to see if you would object. I understood that there was no objection.

Mr. Usina: I was going to find out what it was all about.

The Court: There is no objection to the procedure being followed by Mr. Neave?

Mr. Usina: I do object.

The Court: You do now?

Mr. Usina: Yes.

The Court: Now, what is this letter?

Mr. Neave: It is a letter from Mr. Cole to Mr. Torchio. It leads up to a visit of Mr. Rabé of the New York Edison Company to Boston to see an installation there.

The dates of this correspondence will prove, in addition to Mr. Rabe's own recollection, who is here, the date of this report, which, as a matter of fact, is undated——

Mr. Usina: All of which this witness has no first-hand knowledge of.

Mr. Neave: No, but he has a first-hand knowledge of the letter from Mr. Cole to Mr. Torchio arranging for that visit.

[fol. 172] The Court: That is what I understood.

Mr. Neave: That is all it is.

The Court: If I let part in and keep this out, I could not intelligently consider the whole.

Mr. Neave: No.

Mr. Usina: I object to the whole of it, your Honor. I am sorry that I was delayed in finding out what it was all about with my objection.

The Court: All right. Now, you make an objection to this whole line of testimony?

Mr. Usina: Yes, sir.

The Court: It seems to me that while, of course, your client is not bound as to facts stated, particular facts stated in these letters, it is important where they claim that your client was not the inventor to show his activities prior to the invention.

Mr. Neave: And his knowledge.

The Court: And his knowledge. That is the issue that I am allowing it to come in on.

Mr. Neave: That is all.

The Court: I will overrule the objection and give you an exception.

Mr. Usina: If your Honor please, may I be heard a moment?

The Court: Certainly.

Mr. Usina: This is apparently an effort to prove that Torchio was not the inventor.

The Court: That is what I understood.

Mr. Usina: In the testimony in Cleveland, in the case [fol. 173] in Cleveland, Mr. Torchio testified concerning the origin of the invention and his mind.

Mr. Torchio is not available to us now to testify. He is available to this defendant. He is the vice-president of the New York Edison Company; which is owned by the Consolidated Gas Company, which also owns this defendant.

These gentlemen can bring him in to testify. They can bring the men who wrote these letters and the men to whom these letters were addressed. What they think is material is within the control of the defendants, and I do not think that they should be permitted to introduce anything except under the most strict interpretation of the technical rules of evidence, particularly against hearsay.

Now, my objection is that this witness is testifying merely from hearsay. He sees some letters written by Smith to Jones, and says, "yes, that letter was written by Smith to Jones," and he does not know a thing about it.

Mr. Neave: He says he knows the signatures, and he knows the letters as they came at that time.

Mr. Usina: I think it is secondary evidence.

The Court: It depends on what issues the letters are pointed at. If it was to show that Mr. Smith on such and such a day did certain things, it would be incompetent; but if it is to show a state of mind on the part of the in- [fol. 174] ventor, who is claiming as his prima facie case that he discovered certain things, where the witness is familiar with the general correspondence and certain of the letters have come in without objection, I think that it would be proper for me to so limit the correspondence for the sole purpose, not of showing any particular facts, but of showing a state of mind in the inventor as to his knowledge prior to his application for the patent.

Mr. Usina: I do not think that I should be so severely penalized for my failure to object in time to the first letter which was shown to the witness.

The Court: I shall not consider that. I am not considering that, but I mentioned that fact.

Mr. Usina: I think that is not material.

The Court: Well, I shall overrule your objection, Mr. Usina, and give you an exception.

Mr. Usina: If you will allow me to except.

The Court: Certainly.

Mr. Usina: Not only on that ground, but also on the ground that this further defense, if I anticipate the correspondence, is not stated in the answer.

The Court: I do not know that, but I imagine the question of whether a man is an inventor is raised by the issues taken in the denial of the invention.

Mr. Usina: Yes, but I submit this is not a question of [fol. 175] whether he is the inventor. There is something else which I am endeavoring to understand. Unless it is an attack on his inventorship, I do not see what purpose it has.

The Court: That is the way I look at it.

Mr. Neave: It is not a question of somebody else's invention. I am not trying to prove somebody else invented it.

The Court: Not whether somebody else invented it, but whether or not this is the discovery of the patentee.

Mr. Neave: For instance, in this report of what he learned in Germany, he learned there that compounds were used which were semi-liquid when cold; and having learned that in Germany his patent cannot cover that.

The Court: Well, he might cover that in combination with certain other things.

Mr. Usina: True.

Mr. Neave: He might have known it before he saw it in Germany?

The Court: I know that certain metal is hard. I have learned that from experience. Yet I can use that in a combination with certain other things in useful invention. However, I will overrule the objection, and I think it would be safe, too, Mr. Usina, if you move to strike out the prior testimony as to this correspondence.

Mr. Usina: Thank you, your Honor.

The Court: But I will allow you to make the motion on the ground that you inadvertently were doing something else and did not notice it coming in.

Mr. Usina: All right.

[fol. 176] The Court: I will deny your motion and give you an exception to that.

Mr. Usina: All right. The record will show that.

Q. 39. Is that Mr. Cole's signature?

A. It is.

Q. 40. What is that name at the top of that letter?

A. Mr. Rabé.

Q. 41. Who wrote that?

A. "Mr. Rabe: Note this and my reply." Signed Torchio.

Q. 42. In whose handwriting is this?

A. That is Mr. Torchio's handwriting. There is one other note on there, "Noted A. R.," which is Mr. Rabe's handwriting.

Mr. Neave: I offer this in evidence.

Mr. Usina: The same objection.

The Court: The same ruling.

Mr. Usina: Exception.

The Court: In other words, Mr. Usina, in order to save you the trouble of getting up each time, I understand you object to each and every one of these offers of Mr. Neave along this same line of testimony?

Mr. Usina: Yes, sir.

The Court: The same ruling and an exception in each case.

Mr. Usina: Thank you. I object particularly to the competency of this witness to identify these letters.

The Court: Yes.

(Marked Defendant's Exhibit H in evidence.)

Q. 43. I hand you another letter that purports to be signed by Mr. Cole, dated July 22, 1914. Is that his sig- [fol. 177] nature? It is addressed to Mr. Torchio.

A. Yes, sir.

Q. 44. Do you know whose handwriting it is at the top of that letter?

A. It is "File". It looks like Mr. Torchio's. I think it is.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit I in evidence.)

Mr. Neave: These letters relate to a visit or a proposed visit of Mr. Rabe to Boston to examine some underground cable and junction boxes that were installed there. I understand Mr. Rabe will testify he went to Boston.

Q. 45. Did you ever see a report at that time, that is, in 1914, which Mr. Rabe rendered after his return from Boston?

A. I have seen it, yes, sir, and I have discussed it.

Q. 46. Did you see it that time in 1914?

A. Yes, at the time of Mr. Rabe's return.

Q. 47. Here is something that purports to be a report of Mr. Rabe. Can you identify that as being a report that you read at that time?

A. Yes, sir.

Mr. Neave: I offer this in evidence, and I will state to plaintiff's counsel that Mr. Rabe himself will testify as to that.

(Marked Defendant's Exhibit J in evidence.)

Mr. Neave: Your Honor, the portion of this report which particularly interests me is what Mr. Rabe says about the compound that he saw that was used in a cable which was [fol. 178] laid in Boston, by a British company, the compound used for the British cable. "Compound used by British company at ordinary temperature is about the viscosity of molasses. During the process of joint-making it is heated by a helper over a coke fire to a temperature of 300 degrees F., and allowed to cool to 170 degrees before filling into a joint, thermometers being used to hold to this rule as close as practical."

It will also appear from further testimony in the case that it is the common and usual practice to heat all these materials before they are poured into the joint, I think, so as to get the moisture and air out of the material itself, and also so as when it is heated it will drive the moisture and air more readily out of the joint.

Q. 48. Who, if you know, is or was LeRoy Clark?

A. Mr. Clark was the president of the Safety Insulated Wire & Cable Company.

Q. 49. I hand you a letter which purports to be signed by Mr. Clark and written to Mr. Torchio on July 23, 1914. Do you know Mr. Clark's signature?

A. I think so.

Q. 50. Is that his signature?

A. Yes, sir.

Q. 51. Did that letter come to your attention at the time in connection with these investigations of cable joints?

A. It did.

Mr. Neave: I offer that letter in evidence. Your Honor, it is rather a long one, and I won't read it all to you now. It relates to certain compounds.

(Marked Defendant's Exhibit K in evidence.)

[fol. 179] Q. 52. I have here what purports to be a letter signed by W. H. Cole to Mr. Torchio, dated September 12, 1914. Is that Mr. Cole's signature?

A. Yes, sir.

Q. 53. Did that letter come to your attention at the time?

A. It did.

Q. 54. What is that writing on the top side of it?

A. "Mr. Noe: Have Mr. Rabe see me when samples arrive. T." Standing for Torchio.

Q. 55. Do you know in whose handwriting that is?

A. That is in Mr. Torchio's handwriting, and below that is marked "Done, J. B. Noe," and that is Mr. Noe's signature.

Q. 56. He was one of those working in the New York Edison at that time in connection with this whole matter?

A. He was.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit L in evidence.)

Q. 57. I have here a letter purporting to be from Mr. Torchio to Mr. Clark, dated September 26, 1914. This letter does not bear the signature of Mr. Torchio, it is in there in typewriting. Will you look at that letter and tell we whether you saw it at that time?

A. Yes, sir, I did.

Q. 58. You were working pretty closely in connection with this, and all this was a matter of interest to you during that period?

A. I was very closely related to it; I was held responsible by Mr. Torchio for a large part of the development.

The Court: All of these papers passed through your hands?

[fol. 180] The Witness: Yes, sir.

The Court: At the times and dates mentioned?

The Witness: Yes, sir.

Mr. Neave: I offer this in evidence.

(Marked Defendant's Exhibit M in evidence.)

The Witness: They arrived at my desk either shortly before or immediately after they passed through Mr. Torchio's hands.

Mr. Neave: This, I would like to read you, is a letter from Torchio to Clark, dated September 26, 1914. It is of interest to show where he had gotten by that time and where he had not gotten respecting the subject of compounds for filling joints.

(Mr. Neave reads Defendant's Exhibit M.)

Q. 59. Who in 1914 was Mr. Whipple?

A. Mr. Whipple was the chief chemist of the Safety Insulated Wire & Cable Company.

Q. 60. Where were they located?

A. Bayonne, New Jersey.

Q. 61. Did you know him?

A. I did.

Q. 62. Do you know his signature?

A. Yes, sir.

Q. 63. Is this his signature attached to this purported letter to Mr. Torchio of October 8, 1914?

A. Yes, sir.

Q. 64. Did you see that letter at that time?

A. I did.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit N in evidence.)

Mr. Neave: This letter, your Honor, is with reference to [fol. 181] some compounds that Whipple thought Torchio ought to use that were like the oil that was used in saturating the cable.

Q. 65. I have here what purports to be an office memorandum of the New York Edison Company of October 21, 1914, addressed to Messrs. Smith, McCoy, Stevenson, Rabe and Noe, and the initials in the lower left hand portion of the second sheet are P. T. It bears no signature, but the designation appears in the lower right hand corner "Chief electrical engineer." Did you see that report at the time it was made?

A. I did.

Q. 66. Who rendered that report?

A. This report was rendered by Mr. Torchio.

Q. 67. What are the writings on the top of the first page?

A. The writing on the top is "File, joint study." That is in Mr. Torchio's handwriting.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit O in evidence.)

Mr. Neave: This, your Honor, is a letter written by Mr. Torchio on October 21, 1914. It begins this way. (Mr. Neave reads Defendant's Exhibit O.)

Q. 68. Here appears to be another report or a joint letter from the chief electrical engineer, it is unsigned, to Mr. Lieb, Smith, Maxwell, McCoy, Noe and Rabe, of November 11, 1924. Did that come to your attention at that time, and who was that written by?

A. Yes, that came to my attention and was written by Mr. Torchio.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit P in evidence.)

[fol. 182] Q. 69. I have here what purports to be a letter dated February 2, 1915, addressed to Mr. Smith of the United Electric Company by the chief electrical engineer. Is this letter one of those familiar to you at that time, and who wrote it?

A. This is a letter written by Mr. Torchio to Mr. Smith.

Q. 70. And you knew it at that time?

A. I did.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit Q in evidence.)

Mr. Neave: Your Honor, this is dated February 2, 1915, and Mr. Torchio here, after making a resume of various tests, the results of tests he has made, says this: (Reads from Defendant's Exhibit Q).

Q. 71. On February 23rd, Mr. Torchio writes a letter to Mr. Smith. Is this letter that I show you of that date signed by Mr. Torchio?

A. It is.

Q. 72. Did that come to your attention at the time?

A. It did.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit R in evidence.)

Mr. Neave: One interesting part of this letter of February 23, 1915, by Mr. Torchio, is this: (Reads from Defendant's Exhibit R).

This is also shown by a letter which forms a part of Defendant's answers to interrogatories which the plaintiff has put in evidence, from Mr. Murray of the Metropolitan Device Company, written at the time that corporation was [fol. 183] the owner of this patent.

Mr. Usina: I expect you are going to prove that letter.

Mr. Neave: You put it in evidence, I did not think it would have to be proved.

Mr. Usina: I put it in evidence as the defendant's answer to interrogatories, that is all. That does not prove that the letter is genuine.

Q. 73. Did you ever know Mr. J. B. Murray?

A. I did and still do.

Q. 74. Well,

A. Yes.

Q. 75. Do you know his signature?

A. I do.

Q. 76. Is that his signature attached to that?

Mr. Usina: I object, your Honor. The letter should be proven by somebody who knows it and knows it was sent, and not by a mere recognition of the signature.

Q. 77. Do you know whether that letter was sent and whose signature appears on it?

A. Yes, sir. That is not Mr. Murray's signature.

Q. 78. Not Mr. Murray's signature?

A. No.

Q. 79. Do you know whether that letter was sent to or received by the Brooklyn Edison Company?

A. That letter was received by the Brooklyn Edison Company and referred to me at the time.

Mr. Neave: I offer that in evidence. When the plaintiff puts something in evidence, I thought I didn't have to prove it.

(Marked Defendant's Exhibit S in evidence.)

(Mr. Neave reads Defendant's Exhibit S.)

[fol. 184] Q. 80. All of these letters, except the last one that we have been referring to, were they a part of the general scheme and the work and the conferences and consultations that you were having during that period in 1914 with reference to these joints?

Mr. Usina: Objected to as leading and incompetent.

The Court: Overruled.

A. Yes, sir, they certainly were.

Q. 81. You remember, as you have been in court these last few days, that the Torchio patent says that the supply of oil in the joint can be in the sleeve itself, or can be in an enlargement of the sleeve, in something he calls a reservoir, and you remember it is said in the Torchio patent that this reservoir is merely an enlargement of the sleeve. Is there anything collapsible about it?

A. There is no varying capacity of the Torchio reservoir. The Brooklyn Edison Company never used any reservoir like that. I do not know of anybody who has ever used any reservoir such as the reservoir 10 in the Torchio patent.

Q. 84. Do you remember that yesterday in cross-examining Mr. Waterman, I had some discussion with him, I believe it went into this morning, about whether, if you made up a joint as shown in the Torchio patent, with a hermetically sealed sleeve and reservior which also is hermetically sealed after being completely filled with oil, and the cable contracted after the load had been turned off, and would tend thus to create a vacuum, whether the vacuum [fol. 185] could pull any oil out of that reservoir and sleeve? Do you remember we were talking about that?

A. Yes, sir.

Q. 85. What is your opinion as to whether the cable could pull any oil out of that reservoir and sleeve that are hermetically sealed and are not varying in capacity?

A. It could not.

Q. 86. Mr. Waterman seemed to think it could. I understood him to say he had made no tests. Have you actually proved whether it would or would not, have you made any tests?

A. I have.

The test was made with two reservoirs, the first one filled completely with oil and connected from the bottom of that reservoir through a tube to the second reservoir at approximately the same level. The air was exhausted from the second reservoir up to 20 inches of vacuum, that is, the difference between the pressure in that reservoir and the pressure of air was 20 inches of mercury; and no perceptible quantity of oil was taken from the reservoir. When I say "no perceptible quantity," it would be less than one per cent. of the oil that was drawn from the reservoir.

It is a known fact that you cannot pull oil from a reservoir; it has got to go by pressure, and the only thing that will pull it through is the difference in pressure. With the reservoir filled completely with oil, the instant that there is any release of pressure on the other side and the oil starts to flow, a vacuum is tended to be created, and that vacuum in itself holds the oil in the reservoir in exactly the same manner as the water in the corner over there is held into that bowl. It must have a lot of difference in pressure. After the water bowl is full of water, you cannot suck any water out of that until you get a pressure down to practi- [fol. 186] cally absolute vacuum, meaning no pressure in there at all. So that the joint reservoir shown in the Torchio patent is of no value; it has never been used, it was never used on Torchio's particular joints, and none of his developments have ever used that which he reports in his reports as having given satisfactory results. We could not use a reservoir of that type. That is a simple demonstration that can be made by any physical laboratory.

Q. 88. In the course of your answer you referred to this inverted water bottle in the water cooler in the corner. Some air goes into the top of that water bottle so there is air at the top of the bottle.

A. The only way you can get water out of that bottle is to put air into the bottle. You have to get to a point where the water is down below the bottom point of the bottle.

Q. 89. And you would not get any appreciable amount—any observable amount, of oil out of such a sealed reservoir as the Torchio reservoir until you got to about 20 inches of vacuum?

A. It was well above 20 inches. At 20 inches of vacuum it was just perceptible, and from there up to 30 inches, at 30 inches, of course, you have practically an absolute vacuum and then it would come out.

I have no idea that a cable ever has inside of it a vacuum of as much as 20 inches of mercury. The cable would not stand up if such a high vacuum were present because of the ionization which occurs.

Q. 91. Mr. Waterman testified this morning that the vacuum created in the cable might be two or three inches of mercury. Is that in accordance with your general view?

A. Yes, I would say an outside limit might be 5 inches.

[fol. 187] Q. 92. If you are right in this test and the conclusions you made from this test, the oil that is in the receptacle or in the sleeve in the Torchio patent could permeate the wrappings in the junction box, could it not?

A. When you say "junction box" you mean the sleeve?

Q. 93. Yes.

A. Not the sleeve itself.

Q. 94. Could permeate the wrappings there?

A. Could permeate the wrappings.

Q. 95. And would get into the ends of the cable where the cable had bled a bit?

A. Yes, that would get in there from the impregnation, yes, sir.

But this oil from the Torchio reservoir could not migrate through the cable to a point 20, 30, 100 feet off. There would be no way of getting it without replacing it with air. You must change the volume there in some way. The form of reservoir that is being used by the Brooklyn Edison Company is a variable volume reservoir.

On the drawing, Exhibit No. 23, at the upper right hand side is a reservoir. That reservoir is just like an accordion, made of hard drawn copper, and spun into that shape so that it will give to a degree, the volume will change.

Q. 103. Although it is copper it is limber enough for the accordion action to take place without breaking the copper?

A. It is of course this is not we have never installed a joint as shown here.

Q. 104. As shown in this drawing?

A. Yes.

In these reservoirs that are used by the Brooklyn Edison Company, if the cable should tend to draw oil from the joint sleeve, from the reservoir, oil is perfectly free to flow into the cable because the reservoir collapses. With our method [fol. 188] of installation it is more than free to flow because a pressure is exerted on the top of the reservoir so that there is always a pressure on the oil above atmosphere. That is a fundamental feature; that there is always a pressure above atmosphere. You get that pressure just by putting a weight on top of the accordion.

Asked why is that of advantage to maintain a pressure on there, the witness said: The pressure of oil above atmosphere has several features: First, the desirability of having a pressure there to force the oil into any space that may be created; the second thing is to have the pressure above atmosphere so that if there are any holes in the sleeve or in the wipe, this oil will leak out and moisture never gets in. That is easily detectable, and one of the points of greatest trouble is in the wipe around the lead sleeve of the joint to the lead sheath of the cable, of having pin holes, and if you have a pressure in there always above atmosphere, then the oil may trickle out, and never give you any damage. Air or moisture could not come in.

Q. 110. With this reservoir, let us suppose, for a moment, that this shows the reservoir as the Brooklyn Edison used it, as oil tends to be forced from the cable into the joint sleeve and into the reservoir, what happens to the accordion then?

A. The accordion will expand.

Q. 111. Do you find anything at all of that in the Torchio reservoir?

A. No, sir.

Q. 112. You said a moment ago that you never used anything, the Brooklyn Edison never used anything, such as is shown in the drawing, Plaintiff's Exhibit 23. I do not know that I have exactly quoted your words, but will you

[fol. 189] please tell us what you meant by that that I referred to?

A. The picture shown here, as I understand it, is a combination, that is, taking the picture shown in Mr. Peterson's article of June, which joints as originally installed did not have reservoirs on them, and then combining with it a statement of reservoirs and examples of reservoirs shown in his article in November; and that is shown in his next exhibit showing the reservoir piped to the joint.

The Court: Mr. Neave, I am somewhat at a loss, and I want to be set straight. It is very important that I understand what the defendant's alleged infringing structure is. I understood that it was stipulated that Exhibits 23 and 24, particularly 23, showed the defendant's alleged infringing structure.

Mr. Usina: Not quite that, your Honor; it was stipulated that these publications show defendant's structure.

The Court: And this is nothing but an enlargement of those illustrations.

Mr. Usina: It is a little something more than an enlargement of that illustration. It is this illustration with this addition: The text there describing this illustration says: "An insulating barrel is used inside of the lead sleeve merely for mechanical protection, and the joint is either pressure-filled with petrolatum or oil-filled, and equipped with a collapsible reservoir or the like."

There is the joint copied exactly, with the addition of [fol. 190] what the text describes as "oil filled, and equipped with a collapsible reservoir."

Now, if the witness is going to deny that that fairly describes the defendant's construction, why, we have been misled by the stipulation.

Q. 113. Those are the facts, are they, Mr. Woodrow?

A. The facts are shown in the second sketch or second section, which shows

The Court: Exhibit 24.

A. (continuing:) —the manner in which the collapsible reservoir is connected to our cables; and this is used today, primarily the type of joint that Mr. Neave was wanting to introduce. We have connected some of the other type joints to this reservoir, but the joints that were installed at

the time of Peterson's original paper did not have at that time the collapsible reservoirs on them. That is a second development, and you will notice that there were two papers with six months' difference in them, and symbolizes what we had under study in his first paper, and shows that we must install a reservoir on them.

However, I do not think any of the pictures shown have a reservoir on them in that article; and this is the manner in which we have installed the reservoir, and I believe that has been shown to the defendant.

Mr. Neave: I do not think this is a vital point at all.

The Court: No.

[fol. 191] Mr. Usina: I want to set our witness right, Mr. Waterman, in saying that these were made up from the description which was stipulated to be the defendant's device. At another point he is describing this construction which is shown here, or the other one, the article published by Peterson; and the first collapsible reservoirs installed on the 27,000-volt system were screwed directly to joint nipples? That wasn't to overhead piping connected to a number of them. The first of them were installed and were screwed directly to joint nipples on the casing. It was found later that some other method must be adopted because they do describe means for putting those in, and installations similar to those in Fig. 8 resulted; that is, Fig. 8 (indicating). It isn't my function to correct the witness, of course.

The Court: Do I understand, assuming that the alleged invention consists of a cable—I am not trying to limit the invention, but just for the sake of this question, consists of a cable with a joint, and then the pervious sleeve or stocking covered by an impervious sleeve or stocking hermetically sealed at the end with an opening into the pervious sleeve or stocking, the whole in a bath of fluid, do I understand that while you say that there may be some reaching into the ends of the conductor where it bled at the breaking point, that there can be no migration of oil of this fluid into the conductor any distance at all?

[fol. 192] The Witness: You mean under the plan as shown in the patent?

The Court: Yes, that is what I am talking about.

The Witness: With this reservoir?

The Court: Yes.

The Witness: No, that would not go into the cable any distance.

The Court: In making that statement do you assume that there was oil in the conductor originally as it came from the manufacturer, which caused the bleeding, so to speak?

The Witness: Yes.

The Court: Would there be any effect in the new oil in the receptacle reaching those bleeding ends and coming in contact with the oil already in the conductor, the cohesive action with the oil already there with the new oil which it gets from the receptacle?

The Witness: The capillary attraction in the material themselves would pull a little oil, but it could not pull it—it would pull it from the reservoir, but not from the reservoir in the cable——

The Court: You say it would not pull any distance?

The Witness: It would not pull any distance, because immediately you start to take the oil away you have a counter-pressure established because you start to create a vacuum in your reservoir, and this is a reservoir of the type that will not change in volume.

The Court: So that, if they found oil 50 or 60 feet away, [fol. 193] how would it get there? It must be from another apparatus of some other type, the cable is filled with oil.

Mr. Neave: There is no evidence that with the Torchio form of reservoir they ever found oil that distance away.

The Court: That is what I am asking, it must be from another source.

Mr. Neave: There is no evidence that they ever did find oil.

The Court: It must be from some other source than this device?

The Witness: Yes, the type of reservoir which was mentioned here in Baltimore, you see that was open to the atmosphere, and the atmosphere would push the oil down into the cable. Now, this was not open to the atmosphere in the Torchio reservoir, and therefore you do not have the atmospheric pressure to push it down.

The Court: Because this is hermeticaly sealed?

The Witness: Because this is hermetically sealed.

The Court: Although the oil would reach the bleeding ends of the joint?

The Witness: The oil will naturally reach the bleeding ends of the joint.

Those bleeding ends of the joint are right in the oil, they are in with the oil.

Q. 116. You spoke of a test you made and some apparatus and bottles and things. Can you make a sketch of that so it will be understood more readily?

A. I think it will be easy, yes.

[fol. 194] Mr. Usina: If your Honor please, I object to testimony concerning or tending to prove inoperativeness of the Torchio apparatus as disclosed in this patent, on the ground that there is no such defense raised.

Mr. Neave: I am not urging its inoperativeness; I am urging only that Torchio's oil will—it is only what Torchio says in his patent it will do, and that is permeate the wrappings in the joint and the ends of the cable where it is bled.

The Court: That is satisfactory.

Mr. Usina: He is not urging inoperativeness?

Mr. Neave: I am not urging inoperativeness, but if they say it will do anything more than that, I dispute it.

The Court: In other words, if they told you the oil would go 50 or 75 or 100 feet away, you say it won't do it?

Mr. Neave: It won't do it.

The Court: But so far as what Torchio says it will do, you are not urging it will do otherwise?

Mr. Neave: No, I am just insisting it will do what Torchio says it will, and nothing more.

Mr. Usina: That is all right.

The Court: That is satisfactory?

Mr. Usina: Very.

Mr. Neave: That is, that it will permeate the wrappings in the joint and permeate the ends of the cable where they have bled.

Mr. Usina: Not what Mr. Neave says, but what Mr. Torchio says, is what he agrees to.

[fol. 195] Mr. Neave: I agree to that which Mr. Torchio says.

The Court: That is his construction of what Mr. Torchio says.

Q. 117. This rough sketch you have handed to me shows two spherical things connected together at the bottom by

a tube, and the left spherical thing and the inside of the tube connected at the bottom is cross-hatched, I believe you call it?

A. Yes, sir.

Q. 118. That represents oil?

A. That represents oil.

Q. 119. And a sort of a valve, stop cock stuck up above the left hand one of those spherical things, and that is all filled with oil, and then that cock is turned so as to make it hermetically tight?

A. That is right, yes, sir.

Q. 120. Then, you have attached a vacuum pump and you begin to draw out air from the right hand side?

A. Yes, sir; there is a gauge there.

Q. 121. What are the sizes of those?

A. That was a test bottle about 4 inches in diameter.

Q. 122. It isn't a round thing like that, it isn't spherical, is it?

A. Yes, it was spherical, just a little spherical bottle connected at the bottom with a glass tube.

Q. 123. That is, each of those spheres was about 4 inches in diameter?

A. Yes.

Mr. Neave: Are there any more dimensions that you want on that?

Mr. Usina: I think the thickness of the tube connecting——

Q. 124. How about the thickness of the tube?

A. I would say that was about a quarter of an inch.

[fol. 196] Mr. Usina: Inside diameter?

Q. 125. Is that inside or outside?

A. A quarter of an inch outside diameter; it would be somewhat less on the inside.

Mr. Neave: I offer this sketch in evidence.

The Witness: I think that that tube would be more like three-eighths of an inch.

(Marked Defendant's Exhibit T in evidence.)

Q. 126. Have you got that test apparatus now?

A. Yes, sir.

Q. 127. Where is it, just around the corner?

A. Yes, around in the Johnson Street laboratory.

Q. 128. Of the Brooklyn Edison?

A. Yes, sir.

Q. 129. Very near here?

A. About a block and a half.

Q. 130. And you would be glad to have plaintiff's counsel and expert call and look at it if they want to?

A. Very glad to see them.

Q. 131. They may come this afternoon if they want, after the close of the trial?

A. Yes, sir.

Mr. Neave: That is all.

Cross-examination.

By Mr. Usina:

X Q. 132. Will you kindly just measure the inside diameter of the connecting tube and let us know what that is at the next session?

A. Glad to do that.

X Q. 133. I do not think we need to see it except for that. In the record in the Cleveland suit there were a large [fol. 197] number of exhibits put in by Mr. Torchio and his associates to show the development of this invention. I have no doubt that you were familiar with all of those as they passed through your hands?

A. I do not know anything about the Cleveland suit. I have never read it and was not in attendance. Anything that happened in the office I was familiar with.

X Q. 134. You were familiar with everything that happened in the office in connection with the development of this patented idea by Mr. Torchio or his associates?

A. I wouldn't say the patent I do not know about that; but anything in connection with the development of the joint.

The Court: You can refer to it as a joint or as a joint covering or what?

The Witness: We usually speak of them as the cable joint.

The Court: Cable joint?

The Witness: Yes, sir.

The Court: That includes the whole thing?

The Witness: It includes the whole thing. There is really a lot of different joints connected in there, but we have ordinarily referred to them as a cable joint.

X Q. 135. I call your attention to the testimony in the Cleveland suit of Mr. Noe, Mr. Torchio, and others, of which I will give you a complete list in a moment, referring to the development of this joint, and I will ask you to kindly read over their testimony during the next recess and say whether you agree with the statements made by them, and also to examine the various exhibits put in by them in the [fol. 198] form of test reports, and similar data, and say if you recall that those test reports, copies of which are in this record, are true copies of reports which were made at that time?

Mr. Neave: How many pages do you want him to read?

Mr. Usina: I want him to look at the testimony of a number of these witnesses.

The Court: I believe Mr. Usina, by means of this printed record, will be able to show in printed form what went through the office.

Mr. Neave: Yes.

The Court: Rather than to have individual copies of these introduced.

Mr. Neave: These were not in the record at all.

The Court: But he is entitled to show what was in the record.

Mr. Neave: Why doesn't he ask this witness questions about it?

The Court: Because I suppose this witness wants them to read them through, and it will be an opportune time. He has got to come back to show the dimensions of this tube.

Mr. Neave: You want him to read this through, and then what?

Mr. Usina: Then, appear on the stand and tell us whether the testimony of these witnesses is correct according to his best recollection, and whether the reports which they have submitted in connection with their depositions are true [fol. 199] copies of reports which were made during 1914 and 1915.

Mr. Neave: I object to this witness being asked to take 20 or 30 or 100 pages of testimony and having to read through it.

The Court: So far as whether the witnesses testified correctly, your objection is good, but if there are documents there, or statements which this witness has in his own memory, I assume that they are relevant to this question raised by you as to the evidence given by Mr. Torchio.

Mr. Neave: No objection to that.

The Court: That I think he is entitled to show.

Mr. Neave: Let him show any documents he wants.

The Court: Show any letters or documents that passed through his hands, or correspondence.

X Q. 136. Very well. I will show you Exhibit 30 in the Cleveland case, which purports to be a report of Torchio on certain cable oil splices made February 13, 1915, and ask if you recall a report of that sort, recall that report having been made at about that time? Just take them one at a time, please.

A. These are the reports of the tests on cable joints of the different types.

The Court: You remember those?

The Witness: I recall all those tests very well indeed.

X Q. 137. And they were made on or about the dates stated thereon?

A. Yes; we were making tests from July well on to after this.

[fol. 200] X Q. 138. July, 1914?

A. July, 1914.

X Q. 139. And after February, 1915?

A. Oh, yes.

X Q. 140. And will you just turn one after the other the pages which identify the reports that you recall? I started you with Exhibit 30. Please read the list of exhibits that you can identify, commencing with 30, and following.

A. There is nothing here to show that this is a correct transcription. I assume that that is true. I know the reports to have been made.

The Court: Mr. Usina wants you to take this book back, and you have means to verify that.

The Witness: We will have to get it from the New York Edison Company.

The Court: You have means to do it?

The Witness: Yes, sir.

The Court: If you can't get any information, when you return here, I can give you time to get it.

The Witness: Yes.

X Q. 141. Would you rather take the book and look it over and compare it with your records?

A. If you are wanting me to testify that everything that is set forth in here is correct, I would like to do that.

Mr. Usina: I want you to testify that these are correct copies.

Mr. Neave: Of all those exhibits there?

Mr. Usina: Referring to all the exhibits in there that relate to the Torchio tests, and referring to the reports made to the office, office reports at that time——

[fol. 201] The Court: You know what we want.

The Witness: Yes, I think I do.

The Court: That is it.

Mr. Neave: If the witness finds he hasn't the means to verify those, he will say so.

The Court: Exactly.

Mr. Usina: But he has just said that he has such means, he cannot very well deny it.

Mr. Neave: Your Honor, I do not know just to what extent we can expect this witness to go and look up things that aren't in the possession of his company. They would have to go to another company to get them, and I do not know just where he can find or with what ease he can find those.

Mr. Usina: You can get it as easy as these letters.

The Witness: That would be several days and several weeks' search.

Mr. Usina: I am sorry, your Honor; this is all a surprise to me, this evidence that was entirely in the hands of the defendant.

The Court: Very good, that is all right.

Mr. Usina: And if it takes two or three weeks, I think we should take two or three weeks.

The Court: I won't hold you to any fast rule that interferes with justice in the case.

Mr. Usina: I may say that I asked beforehand counsel, I forget whether it was Mr. Monroe or Mr. Neave, whether [fol. 202] they would consent to the use of all those things

as evidence in this case without taking testimony concerning them, and they had a perfect right, of course, to refuse to do that, and they did refuse.

The Court: My own impression is that we need not worry at all. I think you will find every opportunity given here.

Mr. Neave: If the Brooklyn Edison Company arranges to the extent of its ability that those records go over to Mr. Usina, then let Mr. Usina send them here and use them. Here is the vice-president of the Brooklyn Edison Company, and I am wondering whether he should spend all of his time in checking up those records.

The Court: I think you will find as soon as the Court adjourns that both parties want to get this case tried and the evidence before the Court, and there will be very little trouble.

Mr. Monroe: The exhibits that are now being offered are those used by this plaintiff of its predecessor in the Cleveland case. We are now apparently being asked, at great expense and labor, to do this work for this plaintiff and bring these exhibits in here in shape to be proved. We are being asked at our expense, and at the labor of our witnesses, to go ahead and do that work which they should have done beforehand.

The Court: All right, Mr. Monroe, that is all right. If it was any great labor it would be a different thing, but [fol. 203] here is a printed book, and I do not anticipate any real difficulty with this witness, when he returns, going through these exhibits, and he probably will be able to testify that he remembered these things quite accurately. I do not think you are going to have any great trouble.

Mr. Monroe: It takes up a number of pages of records. It requires the looking up of these records and all of that, these are voluminous.

The Court: You do not want to forget also I have allowed in a general way exhibits to come in in a sense against this plaintiff which he is entitled to meet in the same manner on the question of what was in Mr. Torchio's mind or his knowledge.

Mr. Monroe: But he was an interested party, after all.

Mr. Usina: Oh, no, he isn't.

The Court: I do not know anything about that.

Mr. Neave: I assume when Mr. Usina proved these letters in the Cleveland case, I assume he had the proofs at that time.

The Court: Yes.

Mr. Neave: Have you them now? Because if you have, there is no use——

Mr. Usina: I was going to say, I didn't wish to interrupt, they were returned to the New York Edison after the trial of that case, after I had them myself.

The Court: The witness will do the best he can, but you are limited to the exhibits in this record, and you are not [fol. 204] to take up something more.

Mr. Usina: No, I am not.

The Witness: As I take it, it is from 223 to 293.

Mr. Usina: I will check that. Yes, that is right.

The Court: Now, we will take a recess, gentlemen, until Thursday morning at 10:30.

Brooklyn, N. Y., April 21, 1932.

Met pursuant to adjournment at 10:30 A. M.; present as before.

HARRY R. WOODROW, resumed the stand.

Mr. Usina: On the last day we were here I dictated a statement by Mr. Whittemore, and I intended to offer it in evidence, but I did not do so at the time. I should like to make a clean copy and offer it in evidence.

Mr. Neave: Mr. Usina, it is all in the record, is it not?

Mr. Usina: It is in the record.

The Court: It is in the printed record?

Mr. Neave: It is in the minutes of the trial.

Mr. Usina: It is in the minutes of the trial.

Mr. Neave: I do not see why it should be offered in evidence.

[fol. 205] The Court: It is already before me.

Mr. Usina: Very well.

I want to object, and move to strike out Exhibit S which the defendant offered in this witness' examination, which was a letterhead of the Metropolitan Device Corporation, a letterhead purporting to be signed by the Vice-President, J. B. Murray, which Mr. Woodrow said, however, that he

received that letter. The purport of the letter, as I understand it, which was introduced by the defendant, was to show that the defendant thought that the patent covered only what is called the gauze stocking.

I think that it is immaterial and irrelevant, and not pertinent, and I do not think that the opinion of some identified person in the company that manufactured these joints is competent evidence or is relevant evidence in this case.

The Court: Well, it is in the testimony.

Mr. Usina: Yes.

The Court: And I can give it such weight as I think proper.

Mr. Usina: Very well, your Honor.

The Court: I will deny your motion and give you an exception to preserve your rights, that is all.

Mr. Usina: Thank you. You will note an exception?

The Court: Yes.

Cross-examination, continued.

By Mr. Usina:

I did know something about the Boston installation by the British Insulated and Helsby Cables that have been [fol. 206] referred to in some of the memoranda that I have identified. I did not see it. I acquired knowledge of it from reports that were submitted to us. From the report that I have already identified, the most of the information came to us at that time. I had other information. There was considerable other information passed on from time to time from the engineers of the Boston Edison Company, and the engineers of the New York Edison Company.

I think you understand that the engineers of all these Edison companies have a very close contact, one with the other. And it has always been the practice to give private information between companies, so that a number of letters passed, and from letters and from direct conversations with these engineers we were in pretty close contact with the development in Boston.

Asked if he can get any letters which he had at or about the time of this installation, the witness said: Well, the letters that we had that I was able to find in the old file were the ones that were presented here. The letters which I have produced here do not show the full extent of my

knowledge acquired at that time of the Boston installation.

Asked whether there are any other letters which would give a further knowledge of that installation, the witness said: I thought there were a number of other letters. We could not find them all in the file. Of course, the file is some 15 years old, and just happened to have this particular file which we went over, and found these old letters. [fol. 207] I have produced all the letters that I have been able to find that bear on the subject of that installation.

X Q. 155. So far as relate to the British——

A. I do not think there were any other letters directly bearing on that, except those—with the exception of some other immaterial items.

X Q. 156. Yes.

A. You understand the Boston installation was a special type of cable from some other angles.

X Q. 157. Yes.

A. Because it was a split conductor. There were a few other letters we found in connection with that, but they had nothing to do with the joints.

X Q. 158. You have endeavored to give a truthful picture of it in so far as it has any reference to the present case?

A. I have, Mr. Usina.

X Q. 159. Was it a concentric cable in the Boston installation?

A. The Boston installation?

X Q. 160. Yes. I mean was it made up of concentric cables inside of one lead sheath?

A. The one Boston installation?

X Q. 161. I mean the one by the British Insulated and Helsby Cables.

A. They had one there that was made with the conductors, two conductors in parallel.

X Q. 162. Yes.

A. And those were insulated, one from the other, for relay protective purposes.

X Q. 163. Is that the one you have covered in the report which you have offered in evidence—which you have identified?

A. I think that is covered in Mr. Rabe's report. You saw that, Mr. Usina.

[fol. 208] X Q. 164. That was the one using two cables in one sheath; two cables in parallel in one sheath?

A. With the other cable?

X Q. 165. I understood you to say that there were two cables in parallel.

A. They had one with the two conductors.

X Q. 166. Two conductors in parallel, I mean.

A. In parallel.

X Q. 167. Yes.

A. Inside of the insulation.

X Q. 168. That is the one that is referred to in that report that you identified?

A. There is a reference to that in that report.

X Q. 169. To that?

A. Without looking at the report, I would not say whether that is covered there or not, Mr. Usina.

Mr. Usina: Have you got that report?

Mr. Neave: Yes.

Mr. Usina: What is the number of that exhibit, do you remember?

Mr. Neave: The Rabe report.

The Witness: The Rabe report, yes.

Mr. Neave: Exhibit J.

X Q. 170. Tell me what kind of cables, first, are referred to in that report, Exhibit J, of the British Insulated & Helsby Cables Company?

A. I think it will be clear here if I read it. Cable for subways between Dedham and Norwood was plain lead 3 conductor—132,716 c. m. per phase—Split concentric 0.1" paper between splits—8 32 over concentric conductor and 8 32 jacket, 0.17 lead. This made up a cable 3" in diameter over all. (See Sketch "A".) Reading from page 2.

X Q. 171. Now, Mr. Woodrow, is that the cable, this 3-conductor cable that you have just described, is that the [fol. 209] cable which was jointed, and had a compound of the consistency of molasses poured in somewheres?

A. That is what the report states here, and that is one of them.

X Q. 172. Is that the only cable mentioned in the report in which this type of molasses consistency compound was used?

A. I think it was. Now, let me look this through to make sure. (Examining report.) That seems to be the cable that is covered in this report.

X Q. 173. Now, I may say generally that what I wanted to get is as exact a picture as we can of the complete installation of cable joints and the whole thing.

A. Yes.

X Q. 174. In so far as it has any bearing on the present issues, so we start with this three-conductor cable with the conductors split, as you have said, and that had a lead sheath around it, did it?

A. The three conductors, yes, had the lead sheath around them.

X Q. 175. That lead sheath cable was just buried in the ground, was it not, not in conduits?

A. No, they had some of them in conduits and some of them buried in the ground.

X Q. 176. Yes.

A. They had other types of installations, because the European practice was the burying in the ground basis.

X Q. 177. Yes. Well, was the British insulation installation in conduits?

A. I think there was some of the British installation in conduits.

X Q. 178. All right. That is the British Insulated Company's installation in conduits. What kind of joints, according to the report there, were put on that particular cable that was laid in the conduits?

A. I did not notice that this was differentiated, although [fol. 210] I believe there was some difference. The principle of the oil—I was under the impression they had some of those differently, but it does not seem to be covered here.

X Q. 179. The complete report seemed to me to fail to identify in detail any one type of installation, including cables and the way in which the cables are carried in the ground, and the manholes, and the joints. Isn't it your view that the report is indefinite to that extent?

A. Well, the point we were after, Mr. Usina, is the type of joints. It does not make much difference—

X Q. 180. Oh, I beg your pardon.

A. (Continuing:) —as to whether the joint was in a manhole or open to the air or buried in the ground. I do not

recall that we would materially differentiate as to the position. If it was buried in the ground, or whether you had an open manhole, you would have access to it even though you had the thing buried.

The Court: Was there anything in this report at that time that talked about the joints?

Mr. Usina: Will you please——

The Court (Continuing): Is that right?

Mr. Usina: Yes, sir. I wanted to have the stenographer read the question again.

The Court: Yes.

Mr. Usina: I think he did not get my question. Will you read the question?

(X Q. 179 repeated by the reporter.)

A. Well, here is one paragraph here that I remember quite distinctly. That gives a rather definite statement as [fol. 21] to the way the joint was installed. I am referring to page 4, under "Jointing". The plain—it gives plain and the armored and the split concentric joints.

X Q. 181. What do you mean by "split concentric joints"?

A. That is what we were talking about where they had the two conductors, one inside of the other, concentric.

X Q. 182. You mean a joint then for a split concentric cable?

A. That is right. This is a split concentric conductor, as I would refer to it, because there is another type of cable that is called a concentric cable that has not any reference to those. If you would like, I will read that.

X Q. 183. Very well, if you think that will give us a picture of the complete particular installation.

A. This gives here the armor for a straight concentric joint. "Straight concentric joints are again as above but over the wiped lead sleeve is placed a long split cast iron box, similar to our own Edison tube box, though without clamps. This box is bolted and fits snugly over wire armor at both ends of joint opening, a bond strap having previously been soldered closing this gap. This cast iron box is filled with compound at atmospheric pressure and over all a wooden box, enclosing everything, outer jute to jute, is placed and this filled with common pitch". That is the outside job. That seems to me a rather clear description of that.

X Q. 184. What is the armor to which you referred in that?

A. Well, in the different references to the installation lying in the ground here, the armor is the protection to the lead sleeve.

[fol. 212] X Q. 185. You mean there is something outside of the lead sleeve?

A. When it is laid directly in the ground they will usually have an armor.

X Q. 186. And what is that armor like? Describe it, please.

A. Well, we have many kinds of armor. I do not remember just which this is, but I will describe one kind for you.

X Q. 187. If I may interrupt you, tell me what kind of armor, according to your best recollection, is referred to in that report, Exhibit J. That is what I want to know.

A. As I recall the armor in this one, it is very close to this type of armor, consisting of strands of steel wire placed over a jute covering of the lead sleeve, which is a protection against stones or picks or anything else coming in contact with that lead.

X Q. 188. We had a lead sheath cable of this general character, Exhibit 20; and on the outside of that it had jute, and then outside of that a spiral wrapping of steel wire.

A. Of steel wire.

X Q. 189. Which you call the armor?

A. The armor, yes.

X Q. 192. In the materials which you have identified on your direct examination as having passed under your eyes when you were Mr. Torchio's assistant, have you given us all of such materials that you think are pertinent to the present case?

A. Yes, sir, I have, Mr. Usina.

X Q. 193. When you received the letter from the Metropolitan Device Corporation, signed with the name of J. B. Murray, which you say, however, was not his signature, did you reply to it?

A. I do not think we did, Mr. Usina.

X Q. 194. Have you looked through your files to see [fol. 213] whether you did reply?

A. Yes, we looked through the files, and we did not find any reply to it. We just happened to have run onto this particular one. This is not an engineering file, and not in our usual file.

X Q. 195. What did you do when you got that letter? Did you just file it away or did you take some action as a consequence of it?

A. That was referred, as I recall it, to Mr. Kirke.

Mr. Kirke was at that time outside plant engineer under me and handled the detailed engineering problems of the distribution system of the Brooklyn Edison Company, and apparently Mr. Kirke and Mr. Peterson reviewed the letter, because Kirke referred it to Mr. Peterson. And after they had seen it, they did not take any action in consequence of it that I have any knowledge of.

X Q. 202. Now, this letter was dated May 23, 1927, and a suit on the Torchio patent in Cleveland was commenced in February, 1926. I want to ask, when you received this letter, Exhibit S, did you know that a suit had been brought against the Cleveland Company on this patent?

A. I do not think that I did.

X Q. 203. You learned, I suppose, of the Cleveland suit not long after it had been begun, did you not?

A. Which suit are you referring to? The first one?

X Q. 204. The suit on the Torchio patent.

A. Weren't there two suits on that, Mr. Usina?

X Q. 205. No.

A. I thought there was a first one in the lower court and then it was carried up.

X Q. 206. That was only one suit. There were two proceedings. That was subsequently appealed?

A. Yes.

[fol. 214] X Q. 207. About when did you first hear about the suit?

A. I don't recall that I heard about it until it got into the second stage.

X Q. 208. That is, until it was appealed?

A. Until it was appealed. I do not recall when that was.

I did not know that the joint of the Cleveland Company lacked any gauze stocking in the casing.

X Q. 210. You did not know what construction they had?

A. How do you mean?

X Q. 211. The Cleveland Company, at or about the time of the suits in 1926 and 1927.

A. No, I do not think I knew what they did in 1926 or 1927. I did know when they finally got up to the second stage of the proceeding.

X Q. 212. Well, in the Cleveland case you may take it from me that there were shown in published reports in the Electrical World and in other technical journals of one of the societies, descriptions of the Cleveland joint.

A. Yes.

X Q. 213. You do not recall having read those? They were published before this suit was commenced.

A. Were they?

X Q. 214. Yes. You do not recall having read those?

A. I recall reading one of the articles, but time slips so fast, it is hard to identify. Of course, the Cleveland joint was a single conductor joint, so entirely different from anything that we were doing at that time, we did not pay particular attention to it. We had no 66,000-volt system, and we had no reason for the single conductor application.

X Q. 215. You heard this statement of Mr. Manvel Whittemore that I read into the record, did you not, about a meeting of one of the electrical societies, at which an offer [fol. 215] was made of the settlement of the claims under the Torchio patent?

A. I just heard the end of that, Mr. Usina, I did not hear all of it.

I did not attend a meeting of one of the electrical societies at which an offer of settlement of the claims under the Torchio patent was made, as described in the Electrical World, Plaintiff's Exhibit 26. I can assure you that no officer of the defendant company did. Whether an employee did or not, I cannot say, without checking it up.

X Q. 218. You do not at present know that any employee did so?

A. No, I do not know that that is the case.

X Q. 219. Well, were you not informed that there was such a meeting?

Mr. Neave: Informed when?

Mr. Usina: I will ask him when. I am asking him whether he was informed.

A. Do you mean prior to the meeting or after the meeting?

X Q. 220. Were you informed of it prior to the meeting?

A. No, I do not think so.

X Q. 221. Were you informed of it after the meeting?

A. I do not recall being informed of it at all, Mr. Usina, until just within the last few weeks.

X Q. 222. If your company had been informed of it at all, would you be apt to know it?

A. Yes, if they thought there was any consequence in it.

X Q. 223. Did you ever, until the very recent days, hear of the offer made by Mr. Alexander to Mr. Whittemore, [fol. 216] counsel for General Cable Corporation, which is according to the offer referred to in that exhibit 26?

A. I do not quite get your question. Did I ever hear of an offer?

X Q. 224. Yes.

A. No; I did not.

I have never said that I, and not Mr. Torchio, am the inventor of the oil-filled joint. I do not believe that I am the inventor of that oil-filled joint.

X Q. 227. With an oil-filled joint such as described in the Torchio patent, do you think it is necessary to have a permanent reservoir of oil?

A. Obviously, no, as disclosed at the time of this investigation when the joints were installed, and following this investigation, which was done largely under my direction in the New York Edison Company, reservoirs were not installed.

X Q. 228. In those installations in the New York Edison Company's lines were oil-filled joints installed?

A. Would you mind defining oil there? The reason for it is——

X Q. 229. Very well. I will define it.

A. (continuing): —because we used a rather heavy oil, and there is some similar to vaseline. If you consider that as oil, I would say "Yes".

X Q. 230. And in such vaseline-filled joints was the joint sleeve made of the same size that you would use for a joint filled with paraffin or similar hard compound with that size of cable?

A. Of course, the size of the sleeve is a function of the size of the cable, and the amount of insulation placed on the conductors.

X Q. 231. Do you mean then that the joint sleeve was no larger than you would have made it if you were going to [fol. 217] use paraffin or hard compound for a filler?

A. It would be no larger than I would have made it with the other type. These New York Edison Company's joints were refilled, especially during the earlier installations, from time to time. And when we installed them we sealed the casing hermetically.

It was not necessary to have anything in the nature of a collapsible reservoir or any equivalent for a collapsible reservoir on them and none was installed. They worked satisfactorily.

Asked what was the voltage on those lines, the witness said: There were two lines originally installed on that, and one of them was operated at 24,000 volts. I think we called it 22,000 volts, because that was the delivered voltage 25-cycle, and the other was 15,000 volts, 60 cycles; and in the earlier installations——

X Q. 238. Both of them from 22,000 to 24,000 volts?

A. No, the 60 cycle was 15,600 volts.

X Q. 239. And the other was twenty-two or more?

A. Yes. I might say on the 22,000 volts that that is more or less of a mongrel system, if we may speak of it that way, because it was 22,000 volts between phases of the two, 11,000 volts to ground and having 11,000 volts to the other conductor. It was a single phase suplied to the New Haven system. The stresses, of course, on that, being considerably less than what you would get on the standard 22,000-volt three-phase system.

I first learned of the existence of the Torchio patent in suit here in 1916 or 1917. I don't know whether or not I read the patent about 1916 or 1917. I think I probably did. I think the printed copy of the patent was in my hand at that time.

[fol. 218] X Q. 245. Have you told Mr. Torchio of your intended presentation here of the letters and reports that you have identified under your direct examination by Mr. Neave?

A. Not specifically, Mr. Usina. May I explain?

X Q. 246. Yes, surely.

A. Mr. Torchio turned over to me all of his files, and gave me access to his files, and asked me to take out anything that I thought was of interest; and we have taken them out, and when we take out anything in the file we will return a note stating just what we were taking out, so that his file would not be lost. And that went back to his office.

Whether he ever received them or not, I do not know, so each and every letter and exhibit may or may not have come to his attention that way.

The Court: When did you do that?

The Witness: Oh, I would say within the last four months, probably longer than that; probably within the last six months.

In preparation for the trial of the present suit. Yes, indeed, great care is taken in manufacturing the oil that is used in cable joints. We do not make any of this oil. At times we do purify it. We heat it at times, but I would say as a general practice we do not do other than test. I might say other than test the oil, if the oil shows up satisfactory on test, there is nothing further done with it.

I could not say that the oil is delivered to the workmen who are making a joint in air-tight containers to keep it from contamination with the moisture of the air. We had [fol. 219] at one time the oil delivered in sealed cans, and we were considering the desirability of supplying the cans with just the quantity of oil for each joint. I think that is the way we are doing it today. I have, however, also seen them take oil from a larger container and put it in the joint without that. It is not the practice, and never has been the practice, to carry it in an open vessel. It would be sealed, but not air-tight.

It takes about eight hours to make a joint in one of our high tension cables. It requires a splicer and a splicer's helper to make such a joint. It is a pretty expensive and delicate job.

Oil will absorb moisture generally if you expose it to the air, and different oils will absorb more than others. And it absorbs air also if it is exposed. There is a certain amount of air in the oil.

X Q. 261. I was interested in the work that you heard Mr. Glover testify about in Baltimore. Under the circumstances there it seems to me that the oil which they put into their pot-heads would have absorbed a considerable quantity of moisture from the air, and dust, probably collect dust in the atmosphere of a sub-station; don't you think that is true?

A. No, I would not think so, Mr. Usina.

X Q. 262. Do you not think that it was fairly dirty with things absorbed from the atmosphere?

A. No. If I recall correctly Mr. Glover's testimony, there was a rather tight fit around the tubes, and he put a cork or something of that kind in the opening, and although it would not be air-tight, it would not be susceptible to foreign particles falling into the oil or being drawn into the oil. [fol. 220] X Q. 263. The rubber disc which they used for a cover had to be threaded over the ends of the three cables, did it not, and carried along for five feet or more?

A. Yes.

X Q. 264. From the ends, and slipped over the cable. To that extent that would leave a pretty wide space for air to get through, would it not?

A. I was under the impression that these tubes, I believe, were mica or some other material of that kind, and were slipped over the ends, and they had a rather tight fit between the tube and the rubber, and then taped up on the outside.

X Q. 265. I do not think he said they were taped up on the outside. If they were not, there would be a good deal of air getting in there?

A. No, there would be no air. There would be no means for circulation. You see, air must have some kind of a circulating pathway for air to flow through. If you take a dead air space, as we have referred to it usually, if it has not got two openings there is not much air circulates through; so I wouldn't think there would be much air circulation through that even if there was an opening.

X Q. 266. A draining off of the oil at the bottom would cause a suction of air through any passage, wouldn't it?

A. It would cause a suction of air through any passage. There would be a quantity of air coming in to replace the oil going out.

X Q. 267. Torchio testified in the trial in the Cleveland case that in the experience of the New York Edison Company before the time of his invention, they had no serious dielectric losses on voltages below 15,000. Is that your recollection?

A. Dielectric losses?

[fol. 221] X Q. 268. No serious dielectric losses, is what he testified to.

A. If that is what he meant, I would not agree to it. Dielectric loss is quite a different function than what we are talking about here. There is a dielectric stress. A loss is a loss of power. I assume that is what he means.

X Q. 269. I assume so, too.

A. The amount of loss of power through the dielectric in the New York Edison Company from the time I went there, was almost insignificant.

X Q. 270. That is what he said, that there was no serious dielectric loss on the voltages which they had at the time below 15,000.

A. I doubt if he means the same thing that I am talking about. Does he mean dielectric stresses on there?

X Q. 271. No, he says losses; I think that is what he means. Losses through the dielectric is what he means.

A. I have known Mr. Torchio so long and so well, that I would not expect him to make such a statement as the term of "dielectric losses". If he meant a dielectric stress, a loss from the dielectric stress, which is a loss of the cable——

X Q. 272. Yes.

A. Then that would be a different thing.

X Q. 273. Well, what do you have to say about the dielectric losses of the voltages below 15,000 prior to 1915?

A. Oh, they were very small.

X Q. 274. They were very small?

A. Oh, yes.

X Q. 275. You recall, do you not, that in 1915 the New York Edison Company was faced with the need of supplying current to the New York, New Haven & Hartford Railroad at about 24,000 volts?

A. I think that occurred in 1914, Mr. Usina.

[fol. 222] X Q. 276. Yes.

A. The installation was made in 1915, but I have a very distinct memory of closely following that problem while Mr. Torchio was in Europe that summer in 1914; and in discussing the installation with him immediately after his return.

X Q. 277. Mr. Torchio has testified that previous——

Mr. Neave: Your Honor, I object to Mr. Torchio testifying. If Mr. Usina wants to ask this witness any question——

Mr. Usina: This is cross examination, your Honor. I want to know whether he confirms what I have been adivsed is the fact.

The Court: Did he testify in some suit?

Mr. Usina: Yes, in the Cleveland case.

The Court: Oh, in the Cleveland case.

Mr. Neave: That testimony is not here, your Honor. We cannot get Mr. Torchio's testimony in this case by quoting from another case.

He can find out what this witness' views are on those points without any reference to Mr. Torchio at all.

Mr. Usina: I submit that on cross examination I can tell him what Mr. Torchio testified to and ask him whether he agrees with Mr. Torchio.

Mr. Neave: I will object.

Mr. Usina: That does not bring Mr. Torchio's testimony in here, by merely asking the question.

Mr. Neave: Why is it that he wishes to bring in the Torchio testimony? Why not just ask him the question?

[fol. 223] Mr. Usina: Because I want to reinforce the witness' mind with a knowledge of what Mr. Torchio has said on the subject; and I have a perfect right to do that on cross examination.

Mr. Neave: Mr. Torchio is not here to be cross examined.

The Court: Well, my opinion is that having introduced this testimony to show the alleged knowledge on the part of Torchio prior to his invention, I mean his application for his invention, that while it is not necessarily complaint to any suit, counsel on cross examination can ask this witness whether or not he agrees with certain other utterances set forth by the alleged inventor.

The mere fact that he uses them testifying in a suit does not bring Mr. Torchio into this. It is the question of whether this witness who has identified certain papers on the question of the knowledge of Mr. Torchio, wishes to possibly change his testimony or to throw more light on it.

Mr. Neave: Then I think he ought to ask him. The inquiry should be put to this witness as to the particular point and his knowledge of the same, no matter whether or not Mr. Torchio has testified.

The Court: It is solely to get this witness' testimony, and not Mr. Torchio's.

Mr. Neave: That is it.

Mr. Usina: Exactly so.

The Court: I will allow it. I will overrule the objection and give you an exception, with that understanding.

[fol. 224] X Q. 278. Mr. Torchio testified in the Cleveland case that previous to the—previous to this New Haven installation of your lines carrying 15,600 volts, you had had 88 joint failures in two and a half or three years on 30 miles of cable. Can you recall such figures?

A. I would not recall the exact figures, but we had a large number.

X Q. 279. Do you think that is at least approximately correct?

A. Would you mind reading it?

X Q. 280. 88 joint failures in two and a half or three years on 30 miles of cable carrying 15,600 volts.

A. Yes.

X Q. 281. You recall, do you not, that when the provision for the New Haven road came up, Mr. Torchio started a thorough investigation of the subject of joints, and made numerous experiments on joints at voltages of 25,000 and upward.

A. Yes, soon after the closing of the contract with them.

X Q. 282. Do you remember that among the first lot of joints there were one or two which, for some incidental reason, he entirely submerged in a bath of oil while the test was going on, and that these far outlasted the other joints which he had not thus submerged?

A. I think most of the joints, Mr. Usina, were tested in a bath of oil.

X Q. 283. Yes.

A. I recall very vividly one particular casing that I happened to examine, which showed that oil had gone into the cable some distance. I believe that was your question.

X Q. 284. Yes. Oil had gone into the cable some distance where the joint had been submerged in a bath of oil, do you mean?

A. Yes.

X Q. 285. The joint itself being filled with paraffin or other hard compound?

[fol. 225] A. I would not say whether that was paraffin, but it was of the hard compound type.

X Q. 286. Yes. And don't you remember that it was after the discovery of this oil migrating through the joint

out into the cable, where the joint was under test, that Mr. Torchio and the engineers assisting him made oil-filled joints and tested them?

A. We made oil-filled joints after that, and we had under investigation oil prior to that, I believe, Mr. Usina.

Soon after Mr. Rabe came back from Boston, and by further correspondence with Mr. Cole, we attempted to get the type of oil that was in the cable.

I remember making a trip to the Safety Insulating Company's factory during that period and discussing the thing with Mr. Whipple as to the type of oil that was in the cable; having in mind that we might want to use it in the joints somewhat along the lines of the Boston case.

The Court: That was what year?

The Witness: That was 1914.

The Court: Approximately?

The Witness: 1914. It would be the—well; sometime between September and October or November.

X Q. 287. Up to that time, say the beginning of 1913, was it not the established practice in this country on the higher voltage lines to fill the joint sleeve with a compound which was not so hard as to be brittle at low temperatures, and not so soft as to flow at normal working temperatures?

A. I think the general practice before 1914, as a general rule, was of that kind; and a large number of different [fol. 226] materials were developed during that period.

As a matter of fact, we had a race in the New York Edison Company between the New York Edison Company and the United Electric Light & Power Company with respect to joint developments.

Those two companies are both owned by the Consolidated Gas Company, but different engineering. They are the two electrical companies that supply current in New York City.

X Q. 290. One direct current and the other alternating current, is that the chief difference between them?

A. No—well, the chief difference in Manhattan Island is the United supplies the alternating current and the New York Edison Company supplies direct current.

In the Bronx the New York Edison Company supplies alternating current.

X Q. 291. The Brooklyn Edison Company, this defendant, is also owned by the Consolidated Gas Company, is it not?

A. Well, it is the principal stockholder if that is what you mean.

X Q. 292. It is controlled—the defendant is controlled by the Consolidated Gas Company as its principal stockholder?

A. Through stock ownership, yes.

X Q. 293. After the experiments that were made at the end of 1914 and early 1915, the joint adopted by the New Haven road was made with a filling compound which was so thin as to flow at normal working temperature, was it not?

A. As I recall the compound, we finally adopted, it was either a 60-40 compound or a 70-30 compound, which would be a little lighter than the consistency of vaseline at the [fol. 227] normal temperature of the cable. That would be quite fluid at the normal temperature of the cable. If you are talking about room temperatures it would be somewhat harder.

X Q. 294. Are the joints which were put in for the New Haven line in 1915 still in service?

A. I could not say as to that, but I believe that would be so.

I have not heard of any serions difficulties with them since they were installed. When these joints were put in in 1915, some engineers regarded the use of such a thin compound as a dangerous innovation. Mr. Torchio was adverse to it at first. I remember that we tried to get him to adopt it earlier.

Mr. Roper in Chicago was somewhat adverse to it. They used a type of joint-filling compound with an asphalt base.

I think Mr. Roper's position in the industry and his standing was superintendent of the Street Department. I believe that is what they call it. He was in charge of the Commonwealth Edison Company, of their cable development.

There were a number—a few others that I think held the same view.

I have very vivid recollections that in 1922 to 1924 the United Electric Light & Power Company had a number of failures on their 27,600-volt lines where the joints had

been filled with a hard compound, and that they melted out all the hard compound and replaced it with a filler compound. At the time I was assistant electrical engineer of the Brooklyn Edison Company.

These particular feeders supplied the Brooklyn Edison Company, and we were dependent upon them.

[fol. 228] The compound, I believe, that was used in them, though, Mr. Usina, was not a hard compound. I think it was this same class of compound that Mr. Torchio used in these earlier points, something on the order of a 70-30 compound, or a petrolatum, and they were, some of them were replaced with the lighter compound, and some of the cables had to be replaced. I think there are some sections of it that they are operating at 13,000 volts rather than 27,000 volts.

X Q. 303. They were afraid to put the high voltage on it on account of the weakness of the joints?

A. That was not entirely a joint trouble. It was partly cable trouble too. And the cables, after needing so much attention, were reduced in voltage to 13,200 volts. That was one of the earlier installations of the 27,000-volt cable by the New York Edison Company.

X Q. 304. United Electric Light & Power Company?

A. That was really the United Electric Light & Power Company.

X Q. 305. Yes.

A. Because they were carried through Manhattan at 60 cycles, supplied from the Hell's Gate station on what were the New York & Queens Company's cables, because part of them came through the Queens territory to Brooklyn.

X Q. 306. Mr. Noe, whom you have referred to as, I think, Mr. Torchio's assistant——

A. Yes, sir.

X Q. 306. (Continuing:) —in the Cleveland case offered certain exhibits, 30, 31, 32, 33 and 34, which I hand you, hand-written notes and typewritten letters addressed to Torchio, and relating to tests on joints. I show you these [fol. 229] exhibits and ask if you recall seeing them at about the dates stated thereon? (Handing to witness.)

A. Do you want me to explain these in detail? Because I had these last night and I went over them.

X Q. 307. No, I only want to know whether you recall having seen them at about the dates stated on them. Just

tell me whether you recall having seen them on the dates stated.

A. Yes. I cannot identify definitely all of these five. They are not signed, and do not have any definite identification mark, but they represent interim reports which I saw at the time.

X Q. 308. Do you recognize the handwriting on each of them?

A. Yes, sir, I think I do.

X Q. 309. Tell me whose handwriting they are in.

A. I believe they are Mr. Maxwell's.

Mr. Usina: I offer these in evidence as Plaintiff's Exhibits 27, 28, 29, 30 and 31.

(Marked Plaintiff's Exhibits 27, 28, 29, 30 and 31 in evidence.)

X Q. 310. Now, I show you Exhibits 35, 36, 37, 38, 39, 40, 41 and 42, which were offered by Mr. Noe in the Cleveland suit, and ask you if you recognize the signatures thereon? (Handing to witness.)

A. What is the question?

X Q. 311. Do you recognize the signatures thereon?

A. I do.

X Q. 312. Who is Mr. S. G. Rhodes, whose name is on these reports?

A. Mr. S. G. Rhodes was the engineer of the Meter and Test Departments.

X Q. 313. Of the New York Edison Company?

A. Of the New York Edison Company.

X Q. 314. Who was Mr. Alexander Maxwell whose name is signed to these reports?

A. Mr. Maxwell was chief of the laboratory.

[fol. 230] X Q. 315. Did you see these reports at about the dates stated thereon?

A. I did.

X Q. 316. What does the number "01775" at the bottom of each of these exhibits 35 to 42 mean?

A. That represents, as I remember it, the investigation number of the laboratory.

Mr. Usina: The papers shown the witness are offered in evidence.

(Marked Plaintiff's Exhibits 32, 33, 34, 35, 36, 37, 38 and 39 in evidence.)

X Q. 317. Mr. Noe in the Cleveland suit offered certain drawings which were exhibits 43, 44 and 45, which he said were direct cross-sections of test joints Nos. 20, 23 and 24. I ask you to look at these drawings and say if you recall that any of the test joints which you made at that time were of these three cross-sections?

A. I think so.

X Q. 318. Do you recall all three of these cross-sections?

A. Yes, I recall all three of the cross-sections.

Mr. Usina: The drawings referred to are offered in evidence.

(Marked Plaintiff's Exhibits 40, 41 and 42 in evidence.)

X Q. 319. I show you Exhibit 46 from the Cleveland case, being a report addressed to A. Rabe, General Foreman, not signed, but initialed H. H.—J. Q. Can you tell from these initials who wrote the report?

A. I think that is Haggerty.

X Q. 320. Do you recall that report having been made at about the date indicated thereon?

A. I do.

[fol. 231] X. Q. 321. Who was H. Haggerty?

A. He was one of Mr. Rabe's men, I think he was a foreman in the Cable Works.

Mr. Usina: The paper identified by the witness is offered in evidence.

(Marked Plaintiff's Exhibit 43 in evidence.)

X Q. 322. I show you Exhibit 47, which was in the Cleveland case, being another report to Rabe. Do you recognize the signature of H. Haggerty thereon?

A. Yes, sir.

X Q. 323. Do you recall having seen that report at about the date stated thereon?

A. Yes, sir.

Mr. Usina: The report is offered in evidence.

(Marked Plaintiff's Exhibit 44 in evidence.)

X Q. 324. I also show you certain data sheets or laboratory test sheets with the identifying number "01775"

thereon, being exhibits in the Cleveland case 48 to 54 inclusive, and ask you if you recall these sheets having been made at about the dates stated thereon?

A. No, I do not recall these sheets, because these were laboratory sheets that were held strictly in the laboratory and never allowed to go out except under direct supervision. I have seen some of these sheets in the laboratory while on test but they were never used by us; therefore, I can't identify them, Mr. Usina.

X Q. 325. Well, you can say you have seen some of them?

A. I have seen sheets of this kind.

[fol. 232] X Q. 326. But you can't recall having seen any one of these particular sheets?

A. I think I have, I think I have, Mr. Usina.

The Court: That is what we are trying to find out.

The Witness: But I can't identify them definitely as to which ones it would be, from just the casual glance that I did have at them. I do not doubt their realness at all.

X Q. 327. You do not doubt they are what they purport to be?

A. No, I do not doubt it at all.

X Q. 328. And your reason for believing that is because you were familiar with the laboratory sheets from time to time, you saw them in the ordinary course of your duties?

A. Yes, I did see them.

The Court: You recall seeing sheets similar to those anyhow?

The Witness: Yes, indeed, I do.

The Court: You are not sure but they are the same ones?

The Witness: Oh, I think quite probably they are.

Mr. Usina: The sheets referred to by the witness are offered in evidence.

(Marked Plaintiff's Exhibits 45, 46, 47, 48, 49, 50 and 51 in evidence.)

X Q. 329. I show you also data sheets which were Exhibits in the Cleveland case Nos. 55 to 62, all of which carry the test number "01775", and ask you if you recall having seen [fol. 233] these or any of them?

A. These are exactly in the same category as the last group, and to that extent I can identify them.

The Court: The same answer?

The Witness: Yes.

Mr. Usina: These data sheets referred to by the witness are offered in evidence.

(Marked Plaintiff's Exhibits 52, 53, 54, 55, 56, 57, 58 and 59 in evidence.)

X Q. 330. I show you Plaintiff's Exhibit 63 in the Cleveland case, entitled "Office memorandum", and addressed to J. W. Lieb, Frank W. Smith, A. Maxwell, W. E. McCoy, J. B. Noe, and A. Rabe, and signed Philip Torchio. Do you recognize that as Mr. Torchio's signature?

A. I certainly do.

X Q. 331. And do you recall this office memorandum having been issued at about the date stated thereon?

A. I do.

Mr. Usina: I offer it in evidence.

(Marked Plaintiff's Exhibit 60 in evidence.)

X Q. 332. I show you Exhibits 64 and 65 in the Cleveland case, being an order for a compound called Stanoline, and a memorandum from the Standard Chemical Company, saying they were sending it. Do you recall these having passed through your office at about the dates stated thereon?

A. I do.

Mr. Usina: I offer these in evidence as Plaintiff's Exhibits 61 and 62.

(Marked Plaintiff's Exhibits 61 and 62 in evidence.)

[fol. 234] X Q. 333. Do you recall getting some Stanoline at about that time for the purpose of the tests that were being made?

A. Yes.

X Q. 334. What is Stanoline?

A. Well, Stanoline is a resin oil compound which is rather fluid, very fluid, I should say.

X Q. 335. Do you recall the office memorandum which was Exhibit 66 in the Cleveland case, addressed to Torchio, and signed R. W. Krass, reciting the properties of various filling compounds?

A. Yes, sir.

X Q. 336. Do you recall having seen it at about the date stated thereon?

A. Yes, sir.

Mr. Usina: I offer that in evidence.

(Marked Plaintiff's Exhibit 63 in evidence.)

X Q. 337. What was Mr. Krass' job?

A. I think he was cable engineer. He was cable engineer; whether his title was that or not at that time, I do not know, but that was his job.

X Q. 338. What was Mr. J. W. Lieb's title at that time?

A. Vice President, and I think Associate General Manager, as I remember it.

X Q. 339. And what was Mr. Frank W. Smith's job?

A. Mr. Lieb was with the New York Edison Company and Mr. Smith was Vice-President and General Manager of the United Electric Light & Power Company.

X Q. 340. What was Mr. W. E. McCoy's job?

A. Mr. McCoy was electrical engineer of the United Electric Light & Power Company.

X Q. 341. I show you exhibits in the Cleveland case, Nos. 67, 68 and 69, covering various tests, and ask you if you re- [fol. 235] call that these tests were made at about the period indicated thereon?

A. I do not find any date on this, and I do not recall the tests. I believe this is something that was made more recently.

Mr. Usina: They are not very material, Your Honor; I simply wanted to put them in as I thought to complete the picture. He says he doesn't recall them and I will leave them out.

X Q. 342. On Exhibit 63 the word "splices" is written at the top in pencil. Whose handwriting is that?

A. I think Mr. Torchio's.

X Q. 343. Mr. Torchio testified that in the making of that series of tests that we have been talking about the joints were numbered in succession as they were made for being tested; that is true, is it not?

A. Yes, sir.

X Q. 344. He testified further that Nos. 19 to 36 were made up differently from those which were made up before

No. 19, and differed in two ways: One in the use of a filling compound which was fluid at low operating temperatures, and the other in the provision of a design which would provide a reservoir for an excess of the filling compound. Can you recall whether or not that is——

A. I wouldn't say that they started at 19, but there was a time when we started a group of them using the lighter oils and oils of different consistency, and then of a different type. I should say different shape of lead sleeves, in order to adopt the proper size of sleeve together with the joint.

X Q. 345. A lead sleeve large enough to give you an excess reserve of the filling compound?

[fol. 236] A. Well, excess, yes, it would give you a larger amount, and I believe there is one of them that you showed there in your other sketch with the square top.

X Q. 346. That would give you a certain reserve over and above what you would have had if you had had a round cross-section for your sleeve, would it not?

A. No, I do not think it did turn out that way, Mr. Usina. I believe we only used one with this square top, and it did not turn out very practical. The actual amount of oil contained was less in this one with the square top than with the same size of a round sleeve. I believe that was a 6-inch sleeve hammered down at the top so it was about 5 inches across at the top, and the quantity of oil in that sleeve turned out to be less than in the standard 6-inch sleeve.

X Q. 347. Because for a given amount of periphery a circle will contain a greater area than any other figure, isn't that a true geometric proposition?

A. That is right.

X Q. 348. Didn't it contain a greater quantity of oil above the actual jointed ends of the conductors than you would have had with your ordinary type of sleeve?

A. I do not recall that we ever measured it, and that would depend upon the location of the sleeve in the joint.

X Q. 349. Didn't you make some of these experimental joints with the actual connection between the conductors below the center line of the sleeve?

A. Yes, we tried it with various facings so as to get it off center.

X Q. 350. So as to get a reserve space above?

A. Yes, that is right.

X Q. 351. Mr. Torchio also testified in the Cleveland case [fol. 237] that when he first thought of these oil-filled joints he thought of using a reservoir outside of the sleeve. Do you remember his saying that at the time these experiments were being made?

A. Yes, we discussed that a number of times, because others had done it, and we wanted to get as much reservoir capacity as we could get, and that was discussed throughout this whole investigation, Mr. Usina, a number of times, as to the size of the sleeve. There had been some question among engineers as to what size of sleeve should be used in connection with a joint, how far you should separate the conductors, the three conductors in there, with the size of sleeve around it, and how much space you should leave in between the conductors. There was considerable discussion on that point.

Mr. Usina: Mr. Neave, you do not want me to make photostats of these things, you have them in the printed record in the Cleveland case.

Mr. Neave: All right.

X Q. 352. In your direct testimony you said you knew of nobody who had ever used any reservoir such as the reservoir 10 in the Torchio patent. Did you mean by that that you knew of nobody who had ever used a non-collapsible reservoir in such a combination?

A. As shown in 10 of Fig. 1, I do not know of anybody.

X Q. 355. What is there about the patent drawing that makes you qualify your answer to "As shown in the patent drawing"?

A. Every joint that has ever been constructed has reservoir capacity to a certain extent, more or less, depending on the size. But the particular type as shown at 10 in Fig. [fol. 238] 1, I believe is unused any place.

I have seen non-collapsible reservoirs used in similar locations to that shown in the patent.

There are a number of them that are made now with a reservoir of variable volume, but not collapsible. The variable volume feature is obtained by having an air chamber at the top of the oil, and that air chamber is maintained under pressure to accomplish the same result as you have with the collapsible reservoir with the pressure on the top, that is, maintaining a pressure on the oil above the atmos-

phere. There are a number of those on systems today. I think we have six of them experimentally on our own system. I think we have an experimental installation consisting of six of them, but they are of variable volume in that respect.

X Q. 359. In Exhibit 22, being one of the Peterson articles, on page 1030, at the top, there is a statement of certain collapsible bellows type reservoirs filled with petrolatum and installed at the high joints of this defendant's feeders, being in service for approximately two years, and the text goes on to show that many of the reservoirs were found entirely devoid of oil and others contained large voids, that some of the joints had collapsed, and there were a great number of joint failures. I would like you to read that, commencing at the bottom of page 1029. Did the results stated in that paper differ from those which you would have gotten if you had used a rigid reservoir instead of a collapsible one?

A. No, it refers yes.

X Q. 360. In what respect would these results described in the Peterson paper, Exhibit 22, differ from those which [fol. 239] you would have gotten if you had had rigid reservoirs?

A. If we had had a rigid reservoir on the joints, there wouldn't have been the migration from the reservoir into the cable, and of course you wouldn't have had the collapsible feature, but you would not have had the amount of oil going into the cable. The results which he specifies are after some time the reservoir collapsing with a large number of failures indicated the condition that we would have had in the beginning had we not had some reservoirs of the variable volume type; and therefore the results would have been of an entirely different character unless we had used a non-collapsible reservoir with an air pressure at the top of the reservoir.

X Q. 361. Now, take these collapsible reservoirs that are referred to in this Exhibit 22. After a certain time they will have collapsed to the mechanical limit of their collapsibility, will they not?

A. Not if we knew it ahead of time.

X Q. 362. But I am talking about the time when you were making these experiments?

A. Oh, yes.

They did do that in some cases. After they had collapsed to their limit they became non-collapsible any further.

X Q. 365. In those cases did you not find that even after collapsing to their limit and becoming no further collapsible the oil in these reservoirs migrated into the cable?

A. I do not know that that would be true, and I do not recall specifically an example to indicate it. His statement here says there were collapses of the joints, which indicates that the pressure there was considerably below atmospheric pressure; and whether there was any oil left [fol. 240] in the reservoir or not, I do not know. The collapsible reservoir does go down to a point leaving a very small area inside of it, and our usual practice is to go ahead and refill, forcing the collapsible reservoir back up to its original position.

X Q. 366. But after it has collapsed to its limit, if you do not refill it, you do not know whether oil has migrated further from that reservoir into the cable?

A. I do not know from the facts of the case. I have a theory.

X Q. 367. Well, we will agree you do not know; let us have your theory.

A. If there was no oil left in the joint, and then the oil would be in the reservoir; if there was air entrapped in the joint, then, there might be a different situation develop; but if it was thoroughly filled, as we had tried to do, although this was a very old cable that we were rejuvenating, then there would be oil left up in the reservoir.

If there was any air entrapped in the filler or in the cable it might escape therefrom into the top of the reservoir and let some of the compound down.

I am not familiar with the joints that were installed five or six years ago by the Public Service Corporation of New Jersey in which the joint sleeve merely had an upward enlargement in the form of a dome which carried a reserve supply of oil such as in the picture which I have been shown.

X Q. 370. Have you never heard of that before?

A. Of using a dome, oh, yes. That was brought back, I think it is in evidence here, in some of the German development; Mr. Torchio brought it back in 1914 to us.

[fol. 241] X Q. 371. Did that work in Germany?

A. They said it did.

X Q. 372. Was it collapsible?

A. No.

X Q. 373. Was it variable capacity in the sense that you have defined that?

A. I think in most of those cases they left an air pressure at the top of them, although it doesn't state.

X Q. 374. What is the origin of your thought that they left an air pressure in the top?

A. Because that was and still is today a European practice in a number of cases.

X Q. 375. Have you any written or printed authority for the proposal, I mean particularly the provision of an air pressure at the top?

A. I do not think I have, although I am sure it is in print. The information I am giving you came from the engineers of the—European engineers of the Cable companies over there; we had two of them over here——

Mr. Usina: I object, your Honor. I do not want that part of his answer. I only wanted to know the first part of it, that is to say, whether he had this written or printed authority.

The Witness: No, I do not have it.

X Q. 376. Your answer is "No" to that. Referring to this picture which I have shown you, do you not recall having one such cable sleeve submitted to your company by a salesman for the Metropolitan Device Corporation which was at the time the owner of the patent, I believe?

A. One similar to this?

X Q. 377. Yes.

A. I do not recall any such thing.

[fol. 242] X Q. 378. If such a thing had been submitted to your company it would have been your duty to know it, wouldn't it?

A. At what time?

X Q. 379. Say in 1926 and 1927?

A. Yes, it would.

Mr. Usina: I may have to refer to this later, and I want to show that the witness had no knowledge of it.

The Court: You can mark it for identification.

Mr. Usina: I will have it marked for identification.

(Marked Plaintiff's Exhibit 64 for identification.)

X Q. 380. On the low voltage lines of defendant company, say 1,500 and lower, you still use hard compounds for filling the joints, I mean compounds which will not flow at low working temperatures?

A. We use usually at the very low voltages straight paraffin, and at higher voltages, 4,000 volts, we use in some cases petrolatum and in some cases a filling like Ozite filling, which is an asphalt base and very stiff, pours under rather high temperature, although it will flow in time. For 6600 volts we use a compound very much the same for what little work we do, although I wouldn't be surprised to see a number of those filled with petrolatum in a recent construction. We make very little extension on the low voltage systems except the 120-volt system, and there is not much work done on the others. We have no 13,000 volt system today.

I do not know at what temperature petrolatum will flow readily. Petrolatum has a fairly definite flowing point, although it does change for several degrees, but I do not [fol. 243] recall the temperature at which it does. It is well below, or above the normal room temperature, below the pouring temperature, and I think it would be liquid under the heavy load on the cable, probably under that temperature condition.

X Q. 382. I asked you to give me the size of the tube in your experimental work.

A. It is one-quarter inch inside bore and three-eighth inch outside diameter.

I think the entire sketch is approximately in proportion. I tried to make it as nearly so as possible. I think it is within reasonable limits.

X Q. 384. Referring to this sketch of yours, Exhibit T, you have the level of the liquid in the right hand vessel at the very bottom, and in the left hand vessel clear up to the cock above it. How did you get the liquid at those levels initially?

A. It was poured in or sucked in, I should say, with the pressure on both sides, with a vacuum pump connected to the line at the left, with the line to the right open.

X Q. 385. Until you got the level at the right hand side to where you wanted it, and then you shut off the cock and removed the vacuum pump, is that right?

A. We brought it in until the left hand chamber was entirely full so that there would be no air void left at the top.

At the right hand side we had the level above the bottom tube. That was all that was essential to my experiment.

Mr. Usina: That is all.

Redirect examination.

By Mr. Neave:

R. D. Q. 388. Mr. Woodrow, you will recall that at our session on Tuesday afternoon Mr. Usina handed you a copy [fol. 244] of the printed record in the Cleveland case and asked you to read the exhibits in that case numbered from 30 on, and to get the originals of those exhibits, as I understood, from the New York Edison Company, and be prepared to testify about them today. The record shows that I asked Mr. Usina whether the records were with the New York Edison Company or whether he, Mr. Usina, had them now, and he said that they were returned to the New York Edison Company after the trial in the Cleveland case. Then immediately after the close of court Mr. Usina handed you all those original exhibits, did he not?

A. Yes, sir.

R. D. Q. 389. Numbered from 30 to 69 that you testified about this morning?

A. Yes, sir.

Mr. Usina: I should have explained that fact to the Court when I started here this morning, if I had thought it made the slightest difference.

Mr. Neave: It is only a question of getting the record straight.

Mr. Usina: I am sorry, I was mistaken in thinking that. When the session was over and we were going home, my clerk said, "I think we have those". I said, "Where are they? We must get them if we have". He said, "They may be in this large suitcase of papers that we have", and we looked and found them, and I immediately turned them over to Mr. Neave.

Mr. Neave: Your Honor, I was making no criticism, I was merely straightening the record, because the record [fol. 245] shows he was to make a search which of course he hasn't done, as the papers were handed to him.

The Court: We will take a recess for five minutes.

(A five-minute recess was taken.)

R. D. Q. 390. Mr. Woodrow, you of course are familiar with just how these joints were made in cables and manholes prior to 1914?

A. I was.

R. D. Q. 391. Will you tell us, because it is rather spotty in the record, just assume you had two cable ends, two opposed cable ends coming into a manhole; what did you do to make a joint there?

A. The two cable ends are brought one above the other, and then cut in two and the lead stripped back for a distance of, we will assume, for an 18-inch sleeve long, for a distance of about 7½ inches. The belt insulation is then stripped back for a sufficient distance to expose the three conductors approximately five inches. Then these conductors are spread apart and the insulation on the individual conductors is stripped back for a distance of about an inch and a half. The individual conductors were in many cases, although not necessarily in all cases, tapered, the insulation of the individual conductors. The lead sleeve of 18 inches is slipped on over one end of one of the cables. The other end of the cable goes through the same process as I described for the first.

The individual conductors are then brought together with the insulation separated, and the connector, which is a copper connecter, is placed around the conductors, overlapping the conductors, each conductor say in the order of one inch. [fol. 246] The conductors are then soldered—or before the soldering the connectors are usually brought down as tight as they can with aid of pliers. Then the solder is poured into the connecter until it is all filled, and excess solder of course dropping down below, and usually with a pot below to catch the excess solder. Then this is either filed or an emery cloth used to make that conductor with the connector smooth. The insulation is applied around the conductor and out over the taped insulation to a depth usually 50 per cent. thicker or thereabouts than the mere insulation on the conductor further back. The filler spaces are put in of either jute or paper in between these three conductors to fill up this space, and then all three conductors are then pushed down, and that is all saturated with oil, all of that casing, and usually the paper is an oiled paper that is used. And these are pressed together as tightly as they can be pressed and the space filled in with either jute or paper in

order to make it as nearly a homogeneous mass as possible. And then insulation applied over the whole group of conductors.

The lead sleeve is then moved back over the conductors and the ends beaded down so that they came in contact with the lead sleeve. The ends of that sleeve are then cleaned by a file or sandpaper, and also the lead sleeve of the cable itself, and then a soldering operation is performed to seal the lead sleeve to the cable. That is done on both ends.

The lead sleeve in the old days has simply a hole punched in it and compound was poured in. There were usually two holes in it. Compound was poured into one end until [fol. 247] the cable was full. In the latter practice—when I say "latter practice" I mean in the vintage of 1910, 1911, 1912, in there, when some of them were using vacuum processes, in place of having a hole punched in the lead, they would have a nipple on so they could screw it to a vacuum pump, and then when there was a vacuum there they would let the compound in through the other nipple, which would impregnate that joint as nearly as possible at atmosphere pressure. Sometimes following that we would leave a reservoir sticking up to give some pressure on that oil. The operation was just like a riser on a casting, to fill up the area that was left by contracting. Sometimes they would leave that on with a pressure, depending on the type of joint, so you would be sure to have the joint as nearly filled as possible. Then the nipples would be sealed over air-tight. Sometimes they would leave that on for a day in order to be sure that everything was filled when it was absolutely cooled, because oiled paper insulation not being a very good conductor of heat, it takes some time for that mass to cool and contract to its final state, and after the joint is sealed the operation is over.

I didn't go through the many ramifications or perfections on that, such as taking out the moisture and assuring it by boiling compounnds and boiling oils, and so forth, but in a general way that is the nature of joint construction.

The Court: You had a regular school for that to teach your men?

The Witness: Yes, maintained schools for that. We still have a school, rather extensive school for that.

[fol. 248] R. D. Q. 392. In your answer describing how a joint is made you very frequently used the present tense, such as "is" or "are." Am I to understand that the answer as you gave it applied to the making of joints prior to 1914?

A. Yes, I intended to describe a joint prior to 1914.

R. D. Q. 393. You said that after the ends of the conductors had been bared and were connected together by a connecting sleeve which is soldered on and then smoothed down, you said some insulation was applied. What was the form of that insulation?

A. Well, there are various forms of insulation used. Some of them was a varnished cambric, and some paper. I would say about half and half was used at that time. Some people used varnished cambric tape and others used a paper tape.

R. D. Q. 394. And that was in a strip wound on spirally?

A. That was all wound on spirally, and the strips would be,—well, they varied from a half inch wide on some very fussy joints to an inch wide on the outer belts.

R. D. Q. 395. Then you have said that after the sleeve was wiped on to the ends of the lead sheath of the cable you made a hole or two holes in the sleeve and then poured in the compound, or whatever oily thing was used, hot?

A. Yes, sir.

R. D. Q. 395a. At the present time, even if you use a very thin and easily flowable compound or oil, do you heat it before you pour it in?

A. It is usual practice to use warm oil in order to drive out moisture, hot oil.

R. D. Q. 396. Then you said that where cables were filled by the vacuum process along about 1910, 1911 or 1912, you didn't have two holes in the sleeve, but you had a [fol. 249] nipple. What is this vacuum process that was used then?

A. We did have two holes then.

R. D. Q. 397. You had two holes?

A. The one nipple would be connected to the vacuum pump, and the other hole would be connected to your filling, so you could just turn a valve when the vacuum is on, and after it was on a while, put in the compound.

Asked to tell what that vacuum process was and why he used a vacuum, the witness said: Well, the vacuum process

was used in order to take out as much of the air as possible, so that the compound would flow into the small spaces within the cable, the critical point always being in the crotch, because it was very difficult to get the air out of it unless you used a vacuum. It sort of formed a cup to hold air in there. And that is a point of very high tensile stress, and it breaks down, and we wanted to get as much air out as possible before the compound is let in.

A vacuum was still maintained as a vacuum at the time when the hot oil was poured in. This hot stuff would impregnate it better than if we did not use the vacuum. It would impregnate in the small spaces within the joint that weren't filled with paper or jute. It would impregnate the wrappings of the joint better if a vacuum was used, depending on the type of compound used, how fluid it was. It was put in hot, but some much more fluid than others. And as a result of the use of this vacuum process with this fluid that was poured in hot, that impregnated the ends of the cable where they had bled. You see, at the ends, where we take off the paper, the paper expands out, sort of tends [fol. 250] to unravel, or unwind, I should say; and it would have a tendency to leave little air gaps within the paper itself, and more particularly they are on the belt end of it. And if you do not get the air out, then you do not have the pressure back there equal to atmospheric pressure. If you had a complete vacuum, that would force the compound into the ends of the cable.

The Torchio patent does not describe any means of maintaining the pressure above atmospheric pressure within of throughout the cable.

R. D. Q. 405. Does this patent disclose any means for avoiding breakdowns or failures which were likely to occur in the crotches?

A. No, sir.

R. D. Q. 406. Between these conductors?

A. No, sir.

Mr. Usina: I object to that, your Honor. He is talking about failures that are apt to occur in the crotches, simply leading the witness. Why doesn't he ask the witness what happens?

Mr. Neave: He has already said failures are likely to occur at the crotches.

The Witness: Failures are likely to occur at the crotches.

The Torchio patent does not disclose any means to compensate for volume changes incidental to temperature variation and absorption of the compound by the cable.

R. D. Q. 409. Mr. Woodrow, I would like to clear this up. It seemed a little complicated on Wednesday. Here is a drawing which is Plaintiff's Exhibit 23, that purports to [fol. 251] show the joint that is in the first of the Peterson articles in evidence, and also there is connected, according to this Exhibit 23, a collapsible reservoir at one end of that, of the sleeve of the joint. You said the other day you didn't use that kind of a thing.

Now, will you explain that a little bit more so we may know exactly what the situation is? I think that perhaps you will have to go back to the form of joint or joint box that you used prior to the time that article was published.

A. The original 27,000-volt joints which were used had a wrapping and then a Conducell separator.

R. D. Q. 410. Conducell separator; just tell us what the separator is.

A. A Conducell separator is a separator made of mica with an "S" formation, so that they could shove it in around the conductors and form another barrier between the conductors and give additional insulation.

R. D. Q. 411. It acted to separate the conductors inside the sleeve?

A. That is right; it acted as another barrier there.

R. D. Q. 412. Now, I interrupted you. You said your first separators were of that Conducell spacer type?

A. The next joint, which is the joint described by Mr. Peterson, was the joint substantially as shown in Exhibit 23 without the reservoir. These joints were made by the process described in Mr. Peterson's article and filled under pressure with a gun—they were filled first with liquid petrolatum, hot, then sealed, and refilled from time to time by means of a grease gun. I believe that is intended to show the nipple connection of the Alemite type.

R. D. Q. 413. When you say that, you are referring to the projection up in the left hand corner of the sleeve, as [fol. 252] shown in Exhibit 23?

A. Yes. The Alemite gun is connected to this nipple, and a rather high pressure put on that liquid to force it in, the original filling of these joints not being made under vacuum,

this additional pressure on the outside being easier to apply and accomplishing substantially the same results.

The earlier joints of the Conducell type would give trouble as a result of a creeping action along the Conducell spacer, and a reservoir was applied to some of them in test developments, and a few test installations in the field. The results seem to indicate an improvement, so reservoirs were then installed.

The next stage of the development ran into a cambric wrapping, as the cambric seemed to give a better and easier joint in the conductor itself, it being recognized that the conductors would be bent, and paper not having much tensile strength, would tear on its application. Varnished cambric could be drawn up tight and give a better insulating material.

With the varnished cambric we developed the manhole reservoir which is shown on Exhibit 24. I believe that is the next one. Is that 24?

The Court: That is 24.

The Witness: On Exhibit 24, in which the light oil was used, we having developed in the laboratory a number of tests on different kinds of oil, oil of different viscosity, of different characteristics, using some of the machine oil that was more or less characteristic in foreign cable. Finally we came to the conclusion that, I think it is the General Electric [fol. 253] 10-C oil, or oil of that type, which is similar to the transformer oil, was determined to be the most practical; and a variable volume reservoir installed in the manhole to connect to several joints, and this proved so satisfactory that we went back to the filling of the Peterson, the joint described by Mr. Peterson, with oil and connecting them up to the oil pressure system of the manhole so that we do not have any joints exactly as shown in Exhibit 23.

We have joints that are like Exhibit 23, except for the collapsible reservoir directly attached, that is, we have those joints with the collapsible reservoir attached by piping to a multiplicity of those joints.

R. D. Q. 415. Has it or has it not been commercial practice since 1914, 1915 or 1916, to use hard compounds in these sleeves, I do not mean the Brooklyn Edison sleeves, but in general?

A. Yes, hard compound is used in a large number of cases, particularly on low voltage systems, even on 27,000-volt and 33,000-volt systems.

R. D. Q. 416. Even on those?

A. Yes, some of them used today on those systems.

R. D. Q. 417. On Wednesday you described a test that you made with an apparatus that was illustrated in your pencil sketch that is marked Exhibit T. On cross examination, plaintiff's counsel seemed to be interested in the size of the tube that connected the two vessels, as though they were going to criticize that test because the tube may have been too small.

Have you, since that time, made another test of the same general character?

A. We have.

R. D. Q. 418. And is this the test apparatus over on the table here?

A. It is.

[fol. 254] I will describe the apparatus. The apparatus is made up of a standard joint sleeve with a reservoir similar to that shown on Exhibit 23, with the exception of the reservoir being non-collapsible. That reservoir is connected to the sleeve with the same sized pipe which is sometimes used for making such connection. The reservoir was filled completely with oil and an extension of a glass tube extending about 6 inches above the reservoir to indicate oil movement in the reservoir itself. To the other nipple was applied a vacuum pump and——

R. D. Q. 423. Wait a minute. You filled it with oil first. Was that before the vacuum pump or after?

A. You are right. The complete joint casing and the non-collapsible reservoir was completely filled with oil, as shown in Mr. Torchio's patents, and then the vacuum pump applied to the other nipple. The vacuum pump was put in operation, and measurements were made of the amount to which the oil dropped in the glass tube above the reservoir under the various vacuum conditions. On the vacuum pump line was placed a vacuum indicator to indicate the vacuum in the supply. Up to 20 inches of vacuum—first we will go back. At the reading of 5 inches of vacuum no oil at all came from the reservoir. Going on to 10 inches, no oil; 15 inches of vacuum, no oil, no displacement was perceptible in that small tube. And you will notice that the

tube is contracted at the top to a very small area to indicate the slightest movement. At 20 inches of vacuum there was no movement of the oil from the reservoir. As you went above 20 inches, you could notice a little oil coming down, [fol. 255] above 20 inches of vacuum. At 28 inches of vacuum you had the oil displaced almost to the extent of that tube.

R. D. Q. 423. All of the tube, or the thin portion?

A. No, the whole tube, which is about one per cent. of the total volume. In other words, with a 28-inch vacuum you could pull out that amount of oil, which would be about one per cent.

Of course, 28 inches of vacuum is way in excess of anything you would have in a cable joint, as previously testified to.

R. D. Q. 424. We have that apparatus here, we are looking at it. Now, it isn't possible here, I suppose, to reproduce that experiment, to get that high vacuum?

A. No, I do not think there is a vacuum pump here available.

R. D. Q. 425. If plaintiff's counsel or witnesses wish to see that test repeated, you will repeat it for them?

A. We will in the Johnson Street laboratory, which is two blocks east.

Mr. Neave: Your Honor, I do not want to encumber the record by putting in evidence this large piece of apparatus, but with your permission I will offer in evidence a photograph of it when made.

The Court: Yes, that is right.

HARRY R. WOODROW, resumed the stand.

Redirect examination.

By Mr. Neave, continued:

I have spoken of these collapsible reservoirs that are used by the Brooklyn Edison Company having weights put on top of them so as to exert a pressure.

[fol. 256] This photograph shows two reservoirs with weights on each of them. That weight is in a kind of an

H-shaped thing or U-shaped thing hung over the top of the reservoir.

Mr. Neave: I offer that in evidence.

(Marked Defendant's Exhibit U in evidence.)

R. D. Q. 430. We were talking this morning about this test apparatus of yours that is here in court now—photographs of which are to be put in evidence. Projecting out at each end of the sleeve is what looks like a piece of cable, lead covered cable. Is there actually any cable in those parts?

A. Yes, sir. There is a cable extending through that sleeve. It extends straight through the sleeve. There is nothing else inside the sleeve except that cable and the oil.

The Court: Mr. Neave, could you identify that apparatus and then substitute photostats for it?

Mr. Neave: Yes.

The Court: In other words, the record will show it was in court, and I suppose we can refer to the photostats just as well, and mark this for identification and offer in evidence the photostats.

Mr. Neave: Yes, we can mark a tag.

The Court: Yes.

Mr. Neave: And have the photograph show the tag.

The Court: Exactly.

Mr. Neave: Well, then, I will have this test apparatus photographed, and I will offer that for identification.

[fol. 257] The Court: Yes.

Mr. Neave: And then will put in evidence a photograph of it.

The Court: Is that satisfactory?

Mr. Usina: That is satisfactory, yes, your honor.

(Testing apparatus marked Defendant's Exhibit V for identification.)

Recross-examination.

By Mr. Usina:

In this experimental apparatus which I set up here, a single cable passes without interruption clear through the sleeve. And that has no effect on the operation of our

apparatus. It was just simply for convenience in construction. Around that is a clear space filled with oil, so that, as a matter of fact, that sleeve might just as well be a glass tube such as I have shown in my first sketch. I have simply used a joint sleeve because I wanted to show what would happen with a big thing like that. Now, taking the ordinary joint sleeve, I mean a real one in use, its function is just to cover the joint and to hold the filling compound.

R. X. Q. 439. And in the old joint prior to 1915, after introducing compound and letting it cool and contract and then refilling, as you have described the operation, was anything further needed in order to complete the joint?

A. I think if you can, I would like to have the question read.

(Question repeated by the reporter.)

A. Not so far as this property is concerned. There is fire-proofing and things on the outside, and miscellaneous [fol. 258] other things, but that has nothing to do with this particular application.

R. X. Q. 440. If that joint had been made with an oil filling of the character described in the Torchio patent, instead of the compounds which you had used at that time, would there have been any reason to expect failure of the joint in the crotches?

A. Not to the same extent, but failure did occur.

In this model Exhibit V for identification which I have brought here to show this suction operation on the oil, the sleeve showed no evidence of collapsing in the course of our experiments. On the inside of that sleeve I should have stated there is a reinforcing tube in there of insulating material, and that was just simply put in as a reinforcing in case that the collapsing action should occur. No collapsing of the sleeve occurred on this one.

I think that sleeve of insulating material is made of Micarta, insulation of Micarta, or something of that type. Micarta is not a mica compound. It is a paper, a Bakelite composition; that is, paper wrapped with Bakelite filler and then baked. I should say it is about one-eighth of an inch thick. The lead of the main joint sleeve is a little more than one-eighth. I think it is three-sixteenths.

Mr. Neave: During the course of Mr. Glover's testimony there were certain log-books of the McClellan Alley station in Baltimore that were produced, and it was agreed then that photographs of the outside of those books and of the [fol. 259] pages referred to in connection with those pot heads be substituted. I now offer in evidence those photographs, and suggest that they be marked as one exhibit.

The Court: Yes.

Mr. Usina: All right.

(Marked Defendant's Exhibit W in evidence.)

AUGUST R. RABE, called as a witness on behalf of the defendant, having been duly sworn, testified as follows:

Direct examination.

By Mr. Neave:

I live at No. 158 Manhattan Avenue, Jersey City. I am not in active business. Not connected with any company now.

In 1914, I was connected with the New York Edison Company. Mr. Torchio and Mr. Woodrow were there at the same time.

Q. 7. Mr. Woodrow referred to a report that you made, which is marked in this case as Defendant's Exhibit J. It has to do with some installations that you examined in Boston. You did go to Boston?

A. Yes, sir.

I did examine those installations. The report handed me is the report that I made when I came back, marked Defendant's Exhibit J. I rendered that report to Mr. Torchio.

I handed it to him. I discussed it with him. Went over it with him. The statements contained in that report are correct.

[fol. 260] Cross-examination.

By Mr. Usina:

Mr. Torchio's position at the time that I made this report to him was Chief electrical engineer. He was not

Vice-President at that time, just chief electrical engineer. He had entire control of the experiments that were made following that report of mine in order to develop a joint for the New Haven Railroad.

I saw the installations at Boston myself that I reported on, personally.

I saw both the British Insulated and Helsby Cables installations at Boston.

That installation had more than one kind of cable. There were two kinds. Plain cable to be drawn in a conduit, and another to be laid in the soil. I saw the joints on the cable that was drawn in a conduit. My report describes those joints.

X Q. 26. And will you tell me what part of your report refers particularly to those?

A. To the joints in

X Q. 27. What page, please?

A. I am on 3.

The Court: He is asking you a question, I think.

The Witness: To which part of the system did you refer to particularly?

X Q. 28. I want the joints on the cable that was drawn into ducts, the British Insulated Company's cables?

A. Yes, sir. I will go into the details and separate the G. E. from the British Helsby under the title "English."

X Q. 29. Page, please.

A. Page 5.

X Q. 30. That refers to the English. Now, there were two English cables, did you not say? I mean, one laid in [fol. 264] the earth and the other laid in conduit?

A. Yes, sir.

Referring to the cable that was laid in conduit, there is in this report of mine, Exhibit J, particular reference to the joints that were made on that cable. Under "English," page 5, I say that:

"Following its foreign practice the British Cable Company has made the transposition joint its standard on all concentric split conductor cables of high voltage. Conductors are therefore transposed in each joint on plain and armored types and differ only in their outer construction, whether in subways or open trench."

X Q. 33. What I am interested in is the difference between those that were in subways, and those that were in open trenches, as to their outer construction.

A. Well, in the cable laid in the trench it requires somewhat more protection over the jointing, and that was done with, as I recall, an armor.

You know, I say in the report in the last paragraph, on page 6, I say:

"A split brass casting 7-inch bore with [redacted] wide, flat and ground flange, top and bottom, encloses this joint lead to lead. Upper (having two filler holes) and lower halves are drawn tightly together by threaded holes in lower casting and flathead brass screws through upper shell. The lipped ends extending over lead of cable are poured and [fol. 262] wiped to cable sheath and the split sides of casting tightly soldered with blow torch and bar solder."

I think that covers the method of the outer construction.

X Q. 34. And that was put on the cable that was laid in the earth?

A. Yes, sir.

X Q. 35. But not on the cable that was laid in conduits, is that true?

A. That referred to the cable laid in the soil. That is the armored cable.

X Q. 36. Yes.

A. The joints in the manholes were of the same type, wiped sleeve and packed in fillers always.

X Q. 37. None of these joints had any permanent reservoirs attached to them after the joint was done, did they?

A. Well, that brings up a question. I think I remember a standpipe was brought up, with some filler plugs that was left over night in order to leave any of the compound to recede; and I think that was left in over night and possibly a day more. And then removed.

X Q. 43. These tubes that came up, were they beyond the ends of this cast shell that you put around the joint?

A. The cast shell, that shell was put on afterwards. That is the large all-over enclosure.

X Q. 44. Yes.

A. I think a day after.

Redirect examination.

By Mr. Neave:

R. D. Q. 45. I asked you whether you made this report and gave it to Mr. Torchio, but I do not think I asked you the date on which you did that. I am not interested in the [fol. 263] particular day of the month, but when was it that you made this report, about, and handed it to Mr. Torchio and discussed it with him?

A. I think that report is dated July 27th.

R. D. Q. 46. I thought it was not dated, Mr. Rabe, but I may be wrong (handing to witness).

A. Oh, it is not.

R. D. Q. 47. The copy I have is not dated.

A. I have the date in mind of getting up there, which was the end of July; and I distinctly recall it was urgent. I was coming down from Boston around Cape Cod, and the date is very clear in my mind that it was about August, July 31st, or August 1st.

The Court: Nineteen hundred and what?

The Witness: 1914. The news was, the big news was, war was declared between Germany and our Allies. I remember that very distinctly; it was a very big date in my mind.

R. D. Q. 48. Then you came down to New York a few days after that?

A. Oh, no, it was that same morning, I arrived and went right to my report, because the matter was urgent.

R. D. Q. 49. And then within a day or two after that you had this talk with Mr. Torchio?

A. Yes. I probably only just had time to have my report, photostats, and so forth, made; and I went over to Mr. Torchio's office; and I am quite sure, I am sure Mr. Woodrow can corroborate that, he was there at the time.

R. D. Q. 50. That was the early part of August, 1914?

[fol. 264] A. It must have been not later than the 3rd of August.

Mr. Neave: Your Honor, the defendant's answer in this case was filed on June 2, 1931. On June 15, 1931, Mr. Monroe, on behalf of the defendant, wrote to Mr. Usina, saying, "It is our desire to amend the answer by alleging four

British patents that were set forth in paragraph 7, as prior publications under paragraph 8," and Mr. Usina replied on the 16th, saying that was entirely satisfactory to him, and that the exchange of correspondence might be taken as an amendment.

I assume, Mr. Usina, that my statement on the record may be taken in the place of putting any particular letters in evidence so as to have fewer exhibits.

Mr. Usina: Quite so.

OFFERS EVIDENCE

Mr. Neave: Thank you. Plaintiff has offered in evidence a large number of prior patents and publications, some of them being those that were cited by the Patent Office in connection with the prosecution of the Torchio patent in suit; and others were the additional patents and publications that were set up in the Cleveland case; and in order to make that list complete I would like to offer in evidence those publications that were used in the Cleveland case, which were not included among those publications which Mr. Usina introduced.

[fol. 265] The first is pages 201, 202 and 203 of the Telegraphic Journal and Electrical Review of March 4, 1887.

(Marked Defendant's Exhibit X in evidence.)

Mr. Neave: The second is the title page of a publication of the Standard Underground Cable Company, and pages 43, 108 and 109.

(Marked Defendant's Exhibit Y in evidence.)

Mr. Neave: It is agreed, I suppose, Mr. Usina, that photographic copies of publications may be offered in evidence with the same force as the original, and that the dates of the publications may be taken to be the dates appearing on those photographic copies?

Mr. Usina: By both sides, subject, of course, to correction, if any error appears.

Mr. Neave: I offer in evidence the volume containing references that are new in this case; that were not in the Cleveland case, and were not before the Patent Office. This volume contains the following:

"District of Columbia, Report of Electrical Commission, Document 15, 1892.

"Geipel British patent 11,280 of 1894.

"de Gelder, Dutch article on the Cable System of Amsterdam. Published in 1907.

"Leinp patent 534,802, of 1895.

"The Electrician of 1911 on 'Vacuum Method of Filling Cable Joints.'

[fol. 266] "Vernier British patent 12,146, of 1909.

"Vernier, Journal of Institution of Electrical Engineers, Volume 47, published in 1911, containing a Vernier article entitled 'The Laying and Maintenance of Transmission Cables.'

"The Electrician, March 10, 1911, containing a Vernier article, 'The Laying and Maintenance of Transmission Cables.'"

I ask that that whole book be marked in evidence as one exhibit.

(Marked Defendant's Exhibit Z in evidence.)

JOHN B. WHITEHEAD, called as a witness on behalf of the defendant, having been duly sworn, testified as follows:

Direct examination.

By Mr. Neave:

I live at Baltimore. I am a professor of electrical engineering and Dean of the School of Engineering at Johns Hopkins University. I have been connected with Johns Hopkins University since 1898. A Professor of Electrical Engineering in 1910. Dean of the Faculty of Engineering since 1915.

Before 1898, I was with the Westinghouse Electric & Manufacturing Company for three years in the laboratory [fol. 267] and in their transformer designing department; thereafter for a year with the Niagara Falls Power Company as an operating engineer.

I have an engineering practice outside of my university work. My connections with various engineering societies are as follows: I am a Fellow of the American Institute of Electrical Engineers; a Fellow of the American Physical Society; a member of the National Research Council, being

Chairman of its Committee on Electrical Insulation; a member of the American Association for the Advancement of Science, and also of the Societe Francaise des Electriciens. That is the French national society of electrical engineers.

My work has been along special lines. For the past 20 years I have made a special study of insulation of high voltage transmission conductors; and I have done a considerable amount of research in that field, and published a number of papers in connection with it. That involved an investigation of insulation characteristics or so-called dielectric behavior. In recognition of my work I have recently been made the recipient of the Elliott Cresson gold medal to be awarded by the Franklin Institute in May of this year.

For the past three or more years I have been retained in a consulting capacity by the General Cable Corporation.

No one consulted me with reference to the Torchio patent here in suit before I was asked to consider it for the purpose of this present suit.

I am not connected in any way with the Brooklyn Edison Company, the New York Edison Company, the Consolidated [fol. 268] Gas Company, or the General Electric Company, except with the Brooklyn Edison Company, in connection with the present suit.

I have read the March 9, 1911, paper of Vernier, pages 313-389 of Volume 47 of the Journal of the Institution of Electrical Engineers on "The Laying and Maintenance of Transmission Cables."

Mr. Neave: You may wish to refer to this, your Honor, to page 149; it begins at page 149. It is of prime importance in this case, so we want to look at it very carefully.

The Witness: This refers to cables for transmitting electric power, high voltage currents such as used for the transmission of electricity for power purposes. The paper speaks of devices which are generally used for a working pressure up to 20,000 volts.

Q. 17. What is the character of cable described in this paper? If you refer to the page in the volume, I would be glad if you would refer to both the pages as numbered in the Vernier article, and also the page number in this volume.

A. I refer first to page 163 of the volume and page 325 of the Vernier paper, particularly Figs. 12, 13 and 14. There we see a typical three-conductor high-voltage cable, the joint in the conductors and the oil-impregnated insulation which is referred to in the text on page 326 of the article, page 164 of the volume. That is the tenth line from the bottom. Reference is made to the oil-impregnated insulation.

[fol. 269] So, on returning to the sketches we find the sheath and the joint. There is a reference to the sheath in the text, being found on page 329 of the article, line 12. Lead sleeves. Page 329 of the article being page 167 of our volume.

That is this lead-covered cable having conductors, each of them having oil-impregnated wrappings.

Q. 21. In the cables are the metallic conductors, the paper wrappings and the impregnating oil or compound intended completely to fill the space inside the lead sheath to the exclusion of air?

A. Correct.

Q. 22. What does the Vernier paper disclose as to the effect of any air between the conductors and the insulation?

A. The description—the author's description of the properties of insulation are generally included between pages 323 up to 329, and there are several references to the influence of the presence of air.

You will find the first one on page 323, where he refers—where he says that "the breakdown pressure is enormously reduced if air is present." He means to say there that under high voltage the voltage—the value of the voltage at which the insulation will be punctured or short-circuited or destroyed, will be greatly reduced if air is present.

He refers again on page 326, that is, his page 326, at the top line, to the importance of excluding air.

Then again in the discussion of the paper, at page 389 of his article, which I think is about page 218 of the volume, reference is made to the occurrence of ionization in the air pockets if any such are present.

[fol. 270] Ionization is the actual failure of the air itself under electric stress. It is accompanied by a generation of heat, and by very active chemical gases which attack the insulation; and the elimination of ionization and the

possibility of its occurrence is one of the reasons why we always seek to eliminate air.

Vernier again refers to sparking in the air pockets on his page 326; and he evidently has this phenomenon of ionization in mind.

I think that those are the outstanding references to the effect of air.

Q. 23. In the discussion the term "ionization" is used as applied to any space in the air pockets?

A. Yes, I so understand it.

Q. 24. When any air which may be present in the holes of the insulation, and so forth, becomes ionized, does that lower the dielectric strength or the insulating value of the insulation?

A. Very definitely.

Q. 25. Had this undesirability of voids or air pockets in cable insulation been recognized even prior to the date of the Vernier paper?

A. Yes. I have a quotation here from a book by Perrine, entitled "Conductors for Electrical Distribution," which was published by the Van Nostrand Company in 1903. Speaking on page 122 of that volume of the saturation of the paper and other fibrous material for the insulation of cables, he points out the necessity that such material must be softened or liquefied by heat, and then he makes the following statement:

"But in this country use has only been made of paraffin, Ozocrite, asphaltum, petroleum residuum and resin. Some [fol 271] manufacturers prefer to soften these materials by an oil mixture rather than to use them alone. Rosin with cottonseed oil or resin with resin oil being the favorites, the values of these oils consisting in their power of making the waxes viscous at all temperatures, and allowing any cracks made in the cable under the lead covering to be naturally healed."

That is the end of the quotation.

Q. 26. Does the Vernier paper contemplate that the lead sheathed cable be drawn into passages or ducts or that it be laid in loose earth or otherwise?

Mr. Usina: If your Honor please, I do not see the need of expert testimony to tell us whether this paper says that the cables are to be drawn into ducts or laid in the earth.

The Court: Well—

Mr. Usina: I shall object to it as not proper expert testimony.

The Court: I will allow it and give you an exception. Go ahead.

A. Reference is made to both types of construction in the paper.

Q. 27. Cables, I assume, can be made and transported in only limited lengths. When it is the desire to transmit the electric current for a distance greater than the practical length of the cable does the Vernier paper describe what should be done?

A. Yes. It describes how the junctions between adjacent [fol. 272] lengths are made. It describes the assembly of the joints and the boxes in which they are enclosed.

Q. 28. Take the joints between the ends of the conductors in two opposite cable lengths, what is to be done to the cable lengths, and with what results, according to the Vernier paper?

A. I do not believe I can improve on Mr. Woodrow's description as to how a joint is made, but as to the results, I think he did not refer especially to the loss of some of the compound that occurs when the closed end of the cable is opened for the purpose of stripping the insulation from the cores and connecting them at the joint and reinsulating the joint.

In particular I will quote from page 326 of the Vernier paper, 326 being page 164 of our volume, the twelfth line from the bottom:

"It has been found, however, that there is always a certain amount of air present in the cores and insulation of the cable, due to the impregnating oils of the cables running out when the cable is cut, and also being dried out by the heat in soldering the joints."

Q. 29. Is this running out of the impregnating oil the same thing as has been described by the plaintiff's witnesses in this case as bleeding of the cable?

A. Yes, sir.

Q. 30. The lead sheath and the cable insulation having thus been cut back, as described in the Vernier paper, and the metal joints having been made and the bleeding of the [fol. 273] cable impregnating oils having resulted, what next is done, according to the Vernier paper?

A. Well, obviously, after the joining of the conductors, the next step in the process of assembling the joint is the taping of the individual conductors; and for his description as to this process I will refer to Fig. 12, as he does, on page 325.

Reading from page 324, at the second paragraph:

"The insulation of joints may be provided in either of two methods, first by putting insulation on the conductors themselves, or by spacing them apart and using the filling composition as the sole insulating material. Fig. 12 shows a joint of the former type, in which the cores are in contact after each having been separately insulated by wrapping them with an insulating tape. White linen tape boiled in resin oil just before using is more generally used, but in some cases tapes impregnated with special compounds at the factory have been used. These latter tapes cannot, however, compare with the former, as all tapes are liable to absorb moisture, and by boiling the tape in oil just at the time it is required, all moisture can be extracted with certainty. Insulating tapes boiled in this manner are also saturated with oil, which is squeezed out in the process of wrapping on and fills all crevices between layers."

There is more about the joint, but I pass to page 324, the [fol. 274] third paragraph, where reference is made to the three cores, near the bottom of the page, as follows:

"The three cores, after each being separately insulated, are taped over together by another wrapping of insulating tape over their whole length in order to provide the same thickness of insulation between cores and earth as between the cores themselves."

The joint-box that is described in this Vernier paper is a lead sleeve, as we find from referring to page 327, at about the twelfth line from the bottom; and also on page 329 there is another reference to it, the twelfth line from the top, the lead sleeve is spoken of. That lead sleeve is larger than the cable itself and the joint. The sleeve being connected with the sheath by a wiped joint, such as we have heard described, is also described here. That is referred to particularly on page 329 also.

Q. 33. At this stage when the lead sleeve containing the

joint has been wiped on to the end of the lead-covered cables, is there any opening in the sleeve?

A. Yes, the openings in the joints are shown particularly in Figs. 13 and 15. Figs. 15 is on page 328 and Fig. 16; there are two openings in each of the latter joints.

Asked, what does Vernier disclose as to the function of the oil or joint compound with which the lead sleeve enclosing the joint should be filled, the witness said: He discusses the joint compounds and oils at considerable length. I refer first again to page 324, at about the fourth line from the bottom, where he says:

[fol. 275] "High-grade joint-box compounds possess very high dielectric strength."

I have already stated what dielectric strength means. It is the power of the insulation to withstand high voltages without direct failure.

On page 326, at the fifth line from the top, there is a reference to insulating oil; so that we have two of the prominent insulating characteristics of dielectric materials referred to here, dielectric strength and high insulating power. The two things do not always go together, but this oil is referred to in both relationships.

Then there is another purpose or function of the oil compound; and we will find the method of the impregnation of the tape which goes over the joint on page 326 and also on page 327. We find references to the impregnation of the tape, for instance, at the bottom of page 326:

"The objection to having oil-impregnated tapes surrounded by a solid compound which does not keep the tapes impregnated still exists, however, and for this reason an oil filling should in such cases be used."

So impregnation is another purpose of the oil, and I find still a third one, namely, to fill these air holes that are caused by the first shrinking of the joint-box compound and the bleeding of the cable. When it is cut they are not ordinarily filled by hard compound. Therefore, the author is recommending the use of an oil or viscous compound which [fol. 276] will flow into all these cavities and air holes. Special reference to these is found on page 327, beginning at the twelfth line from the bottom:

"This lead sleeve is then filled in *which* the insulating composition, either an oil or a viscous joint-box compound * * * which can run into the tubes and all parts of the joint-box."

Asked what, if anything, does the Vernier paper disclose as to any prejudice against the use of a freely flowing oil in the joint box, the witness said: In advocating this freely flowing oil he refers to a prejudice or objection on the part of some engineers. Reference is made to this at the sixth line from the top of page 326, where he says:

"Oil is objected to by many engineers, who fear its being absorbed by the cores of the cables, and who therefore insist on a joint box compound being used."

Asked what does Vernier disclose as to his experience as to whether this has ever injured the joint, the witness said: We read on the same page:

"Although one hears this absorption of the oil frequently mentioned, the author has yet to meet a case where a breakdown has occurred from this cause, and with cables impregnated under vacuum, as E. H. T. " that, I take it, means "extra high tension.", "as E. H. T. (extra high tension) [fol. 277] cables always are, the leakage should in any case be very small."

Asked what, if any, comments he had to make about this apparent prejudice from Vernier's description, as stated in his paper, the witness stated: I think it is obvious in the survey or history of the development of impregnated paper insulated cable and joints that in the early days the impregnation of cables was far from perfect, which means that there were a good many voids and air pockets in these early cables. As a consequence, any tendency to use the fluid compounds that were used in the cables, or even more fluid compounds, was attended by drainage out of the compound into the voids in the imperfectly impregnated cables.

Vernier calls attention here to the improvements that had been effected in the methods of assembling and impregnating the insulation of cables, and indicates that that danger of leakage has been practically eliminated in his experience. That hard compounds which had been used in place of the more desirable fluid compounds, which had been

adopted so as to avoid the draining up into the cables, Vernier now states that he finds that that danger is eliminated, and that he can adopt the liquid compounds with all their attendant advantages.

Asked whether Vernier recommends the use of a joint box compound which will harden on cooling, the witness said: He does not. He particularly warns against that, and points out the value of the fluid compound.

Q. 240. What do you find on page 324 about the disadvantages, according to his view, of the hard compound?

[fol. 278] A. Do you mean at the foot of page 324?

Q. 41. Yes.

A. "High-grade joint box compounds possess very high dielectric strength and withstand higher breakdown pressures than insulating tapes, but their great disadvantage is the considerable shrinkage which takes place on cooling, and the liability, if of a solid nature, for blow-holes or air-pockets to form in their mass."

Q. 42. What kind of insulating oil or compound does Vernier recommend?

Mr. Usina: If your Honor please, I ask leave to renew my objection. It seems to me that the witness is doing nothing but what the Court and counsel can do, reading what Vernier says. If there are any technical points that are obscure to the Court or to ordinary laymen like ourselves, I should be glad to hear them explained, but otherwise I think this is a waste of time and improper.

Mr. Neave: I am trying to be of some assistance to the Court. This is a very long paper.

The Court: I know, but it is very interesting.

Mr. Neave: I mean it is a long publication.

The Court: I know it is.

Mr. Neave: It can be put in briefly.

The Court: We have got half way through it now.

Mr. Neave: I think it may do good to call particular attention to the particular points.

[fol. 279] The Court: If you want, for the sake of the record, to show the high spots in the paper, that is one thing, but going through a whole long document, I do think that Mr. Usina has some right to object.

Mr. Usina: When your Honor refers to the high spots, I recall what Judge Learned Hand told me once, that he

could tell just as well as the witness what they were. He did not need an expert for it.

The Court: I think that is true in the present case.

Mr. Neave: The purpose of this is when we have a long publication, we are not going through that publication, but we are just telling for your Honor's convenience

The Court: So that I can look at it.

Mr. Neave (Continuing): the points that are there.

The Court: That is what I thought you were doing.

Mr. Neave: That is all.

Mr. Usina: All right. Mr. Neave can tell it in his brief. I do not think we need to have Dr. Whitehead tell us.

Mr. Neave: I think this will shorten it:

Q. 43. The question was, Doctor, what kind of insulating oil or compound does Vernier recommend?

A. "Joints of either type" — speaking now, quoting now from the top of page 326 — "may be filled either with an insulating oil or a joint box compound of a solid or viscous nature." He goes on to say he thinks it important that a joint insulated in the manner shown in Fig. 12 should be [fol. 280] filled with an oil, and that the outer insulation over the three cores should be put on in the form of bands at intervals along the cores so as to allow the greatest possible freedom of access to the oil and keep the insulating tapes constantly impregnated. This would be greatly assisted by the constant temperature changes which the cable undergoes under changes of load.

Then referring to Fig. 13, a joint which he prefers as we find on page 327, at the opening of the third paragraph, he said, "In this type of joint insulation is provided with loosely fitting tubes; then this lead sleeve is then filled with insulating composition, either of oil or a viscous joint-box compound, preferably the latter, which can run into the tubes and all parts of the joint-box." He goes on to say that such a compound must be viscous, and of about the consistency of thick cream at ordinary temperatures, and heated it should run as freely as heated oil, so as to penetrate all crevices. It must retain these features throughout its life.

Q. 45. Then I see on page 329 this:

"Oils such as resin or other cable-impregnating oils have been frequently referred to as suitable filling compounds."

What do you understand is meant by "cable impregnating oil," the same kind of oil as is used in impregnating cable?

A. Yes.

Q. 46. Then he goes on to say that if they are used they must always be carefully freed from all moisture before use. Now, how does that ——

A. I did not understand you.

[fol. 281] Q. 47. That is, he says that the oils must always be carefully freed from all moisture before use. Reference has been made already in the testimony in this case to the heating of these oils or compounds before they are poured. Does that have to do with freeing of moisture?

A. Well, the oils are often evacuated and always heated in order to drive out the air which is absorbed by the oils, and moisture which is always present to a certain extent; and so he says that the oils are heated to eliminate air and moisture, and also so as to make the oil run freely and penetrate all the crevices and drive out the air pockets that are in the joint.

Q. 48. At the end of this paper occurs a discussion in which a good many people took part. On page 342, I find that Mr. Roger Smith, describing the 6500 volt three phase paper insulated lead covered cables of the Great Western Railway, states that joints were filled "with a fluid compound and reports great satisfaction." What do you understand to be meant by a fluid compound?

A. Well, in Mr. Smith's remarks, and this is so of the other engineers who discussed this paper, there is a constant contrast more or less specific, and certainly implied, between hard compounds and those which are fluid at ordinary temperatures. You have already referred to Mr. Smith's compound, and we have another from Mr. Hunter, on page 358, near the top:

"As regards jointing, I have no hesitation in predicting that the joint filled with soft compound after it has been exhausted by a vacuum pump will become universal for [fol. 282] high-pressure systems. Anyone who has had experience of the trouble encountered with joints on high-tension cables, practically all of which is attributable to air or moisture, will certainly agree with this view."

And then Mr. Harris, on page 362, near the bottom, he speaks of some 30,000-volt cables and their joint, the joint that he has adopted——

Mr. Usina: What page is that, Doctor?

The Witness: That is page 362 of the Vernier article, page 200 of the volume.

A. (Continuing:) "Consists, essentially, of impregnated paper cylinder * * *." "The sleeve is filled with compound of the consistency of vaseline when cold, but very liquid when hot. The exclusion of all air and moisture is secured by exhausting the sleeve * * *." "A very high degree of vacuum is thus obtained and all moisture is got rid of * * *." "The compound, when poured into the joint, so treated, is able to flood the inside of the sleeve, neither moisture nor air being present."

Q. 49. In this Vernier paper, after the sleeve has been filled with the oil or viscous compound is it left open at the top, or is it sealed?

A. There are two openings in the top, but after the sleeve is filled these openings are closed.

Q. 50. If the compound used is of the consistency of vaseline when cold, or of the consistency of thick cream at ordinary temperatures, will such compound be of such character that it will continue to permeate pervious insulating [fol. 283] tapes and flow to fill the joints at the common working temperature of cables?

A. Yes, it will.

Q. 51. In the Vernier paper does the joint sleeve contain more oil or viscous compound than is necessary to cover the joint?

A. Yes. If we refer to the figures we find particularly in the joint favored by the author, being Fig. 13, also Figs. 15 and 16 particularly, a great deal of joint-box space in excess of that necessary to cover the joint.

Q. 52. You have, of course, read the Torchio patent in suit, and I wish that having in mind this Vernier paper of 1911, you will tell me whether Torchio was the first to discover that loss of dielectric strength was due in part to the bleeding of the insulating compound from the exposed cable ends during installation?

Mr. Usina: I object, your Honor. That is the function of the Court, pure and simple. He can tell us what he finds in these prior publications, if he likes, but that is all.

The Court: That is the purpose of your question, isn't it, so as to make a definite comparison? Let him point it out.

Mr. Usina: Then I object to the question, to the form of the question.

The Court: Yes, the form of the question is perhaps objectionable.

Mr. Neave: Of course, it might be thought to be leading, but I can change it by saying whether or not Torchio says.

Mr. Usina: I do not think that would be proper.

The Court: No, not as to Torchio.

[fol. 284] Mr. Usina: Ask him what he finds in the prior art.

The Court: Yes; I shall sustain that objection.

Q. 53. Very well, Doctor. In the Vernier paper of 1911, these questions I shall ask you by way of summary of what you have said, in the Vernier paper of 1911 is it disclosed that loss of dielectric strength is due in part to the bleeding of the insulating compound from the exposed cable ends during installation of the joint?

Mr. Usina: I object to that unless the witness be asked to point it out.

Mr. Neave: He has already done that, and I have told him this is a summary.

The Court: I will allow that.

A. I have already referred to the loss of a certain amount of the compound when the cable is cut for jointing, and also to Vernier's comments on the effect of air which is admitted to the ends of the cable when they are so cut. He has also called attention to the difficulty of eliminating and maintaining the elimination of air in the use of hard compounds, pointed out the importance of eliminating the air either by evacuation or by the use of a soft joint compound which will flow into these openings.

Q. 54. Does the Vernier paper of 1911 disclose the thing that has been talked of here by the plaintiff as the breathing of the cable, either the article itself or the discussion in connection with it?

A. Yes, I find a number of references which indicate that [fol. 285] this phenomenon was recognized and in the minds of Vernier and those who have commented on his paper, some of those, although the term "breathing" has not been used here to describe it.

Q. 55. So far as you know, Doctor, has that term in connection with cables been one that has been coined by these plaintiffs?

Mr. Usina: Oh, certainly that is objectionable.
The Court: Yes, I think it is.

Q. 56. Do you hear it in your ordinary practice?
A. Oh, I have heard the word "breathing".
Q. 57. You have heard it?
A. Yes.
Q. 58. I didn't know whether it was a regular term.
A. I do not know that I would agree that it is entirely appropriate as a title.
Q. 59. We understand what it is that the plaintiff means by that term. Did you find that in the Vernier paper, or the discussions in connection with it?
A. Yes, I find several references. Mr. Brown, in discussing the paper, on page 350, refers to the alternate expansion and contraction of the cores in relation to the shifting of the compound to and from the box. He also introduces the subject of capillary action, too; but he is referring to the thermal expansion and contraction.

Then Mr. Morton, on page 353, says, "with reference to joint-box compounds, these all possess a high coefficient of expansion, and this not only accounts for the difficulty in filling boxes, but probably accounts for many a case of what is usually called leakage." And when he says "leakage", [fol. 286] there, he obviously means the leakage of the oil into the cable. "A cable running warm causes this compound to expand if this is possible, and probably the absorption of oil mentioned by Mr. Vernier is due to this, rather than to leakage or absorption up the cores," and so on.

Then Vernier himself has one or two references which indicate that he has very clearly in mind the importance of temperature change to the possible movement of oil. In particular, on page 326, at lines 7 and 9, he speaks of absorption of the cable where he is talking about the objection of engineers, and then in another place he refers to constant temperature changes in the cable in their effect on the movement of the oil in the boxes: All of which indicate to me very clearly that all of the people taking part in this discussion recognized the importance of temperature changes on the shifting of oils.

Q. 60. Does the Vernier paper teach that the insulating compound in the joint should not be soft enough to flow, or

does it teach on the contrary that that insulation should be soft enough to flow?

A. It teaches very definitely that it should be soft enough to flow.

Q. 61. Is there anything disclosed in the Vernier paper that teaches that the compound should not be permitted to escape and leave the joint unprotected, or that it should be permitted to escape and leave the joint unprotected?

A. I am afraid I haven't followed your question entirely.

(Question repeated by the reporter.)

A. There is a great deal in the paper which teaches that [fol. 287] the joint should not be, that the compound or oil should not be allowed to escape and leave the joint unprotected.

Q. 62. What would be the result of leaving the joint unprotected? Did anybody ever want to do that?

A. I do not think so.

Q. 63. You have never heard of it?

A. I have never heard of anyone doing that.

Q. 64. Does Vernier disclose a body of pervious insulating material enclosing or wrapping the joined conductors?

A. Yes, he does. I think perhaps I have already referred to that part of the paper in which this is indicated, but in particular I have in my notes here, on page 324, referring to Fig. 12, reference is made to the insulating tape, white linen tape boiled in resin oil, and the three conductors afterwards all taped together with this linen tape which is a pervious insulating material.

Q. 65. Does Vernier disclose means of supplying the insulating oil or other liquid in quantities sufficient to supply any deficiencies in the sleeve caused by absorption and breathing of the cable so that the joint will continue submerged in a bath of insulating oil?

A. That is really the important point that he is making throughout these pages. On page 326, lines 12 to 16, the author, bearing on this point, says that a joint insulated in the manner shown in Fig. 12 should be filled with an oil, and that the outer insulation over the three cores should be put on in the form of bands at intervals along the cores. The cores should also be separated at intervals by similar bands of insulating tape so as to allow the greatest possible

freedom of access to the oil which will keep the insulating tapes constantly impregnated.

[fol. 288] Then again, referring to the joint which is insulated by tubes, page 327, at the middle, I read again that: "In this type of joint the insulation is provided by loosely fitting tubes, preferably Micanite, which are sprung over the cores, the lead sleeve is then filled with insulating composition, either an oil or a viscous joint-box compound, preferably the latter, which can run into the tubes and all parts of the joint-box."

Then he goes on and refers to the properties of the compound as to its viscosity, and it must be about the consistency of thick cream at ordinary temperatures, and when heated it should run as freely as heated oil so as to penetrate all the crevices; and in fact the whole discussion here, he refers again to oil such as resin oil, or cable-lubricating oils have been frequently referred to as suitable compounds for filling. The whole discussion indicates his insistency on fluidity at low temperatures. He speaks, for example, of using compounds which never set.

Q. 66. How long has it been known that oil and oily compounds possess dielectric strength, and how long have they been used as insulating mediums?

A. Longer than I can remember. I used them myself in 1891.

Q. 68. What is the advantage of putting in the oil by the vacuum process?

A. It completely removes the air not only from the openings between the conductors and in the crotches of the three-conductor cable, and the openings that have been caused by jointing, but beyond that the air is withdrawn from the fibrous texture of the insulating material and penetration is thereby very much more perfect; impregna- [fol. 289] tion is more perfect, and the insulating qualities of the fibrous insulation are greatly improved.

Q. 69. What old and well-known instances can you cite of the use of a reservoir supply of fluid to a chamber which is known to tend to become depleted?

A. Well, we can think of any number of instances of reservoirs, overhead tanks of all descriptions. We have heard several referred to here:

The pot-heads of the Baltimore Consolidated Cables were reservoirs in that sense. The water bottle in the corner of

the room was referred to yesterday. In fact, any overhead tank which can be liberated by the admission of pressure above it could be considered as a reservoir, I think.

Q. 70. Are these some oil cups that are arranged that way?

A. Oil cups?

Q. 17. Yes, on machines.

A. A very definite instance of a reservoir.

Q. 72. What is that arrangement?

A. The oil cup on a rotating, on the bearing of a rotating machine, is a chamber which is filled with a lubricant which is fairly fluid, and which is admitted through a small aperture to the bearing at a rate at which the bearing consumes it. The oil passes out of the oil cup freely, limited only by the opening in the bottom, by reason of the fact that it is open to the atmosphere at the top.

Mr. Neave: I will say as to the de Gelder article, which is one of those in the volume marked Defendant's Exhibit Z here, that all we have here is the translation, because the original is in the Dutch language that we are not very expert in.

[fol. 290] The Court: I understand.

Mr. Neave: And we have furnished a copy of that translation to Mr. Usina, and if he has any objection to the translation, a witness will be called upon to translate it.

Cross-examination.

By Mr. Usina:

X Q. 73. You referred to the testimony of witnesses here concerning the filling of certain pot-heads with oil, and I want to ask you whether, in the situation of those pot-heads, they wouldn't be subject to the admission of moisture, dust and coal dust and air in the station?

A. To some extent, yes, sir. I understand that they were covered, which would protect them to a certain extent from any dirty deposits, but they were open to the air and in such a case the oil would take up a certain amount of air by absorption.

X Q. 74. And floating in the air there are particles of moisture and of coal dust in such a station section?

A. Yes.

X Q. 75. Those things, if they got into the insulation of a cable, of a high tension cable, would seriously affect the dielectric properties of the insulation on it?

A. Well, it is a relative question entirely. Undoubtedly in that case the cables were greatly improved by reason of the filling of the voids which had occurred because they were imperfectly impregnated, and the condition would undoubtedly have been better if the oil that was admitted was completely free from all air and moisture. The deterioration of oils is a rather slow process; and I do not think it is at all surprising that the cables were very [fol. 291] greatly improved. But they might have been even stronger if the oil which was admitted to them had been completely protected.

X Q. 76. Yes, this dirty oil, if we may call it that for short, was better than no oil at all?

A. I do not think you can characterize it as dirty oil.

X Q. 77. Well, impure oil or uncleaned oil; how would you call it?

A. I think those are all rather exaggerated terms for it, because the oil was very carefully protected when it went in.

X Q. 78. Suppose we call it impure oil, then, because I cannot think of a better term at the present time. You say that this what we call impure oil was better than no oil at all?

A. I do not admit the word "impure".

X Q. 79. Will you find me a better word for this oil which was originally provided in sealed containers?

A. I do not think you can call it impure oil because it was the oil which was supplied as an oil which would go into the impregnation of cables, and as such it was undoubtedly very carefully protected.

X Q. 80. Do you know that it was carefully protected?

A. No.

X Q. 81. They drew it out of a barrel into a vessel of some kind?

A. A barrel that was shipped by the manufacturer of the cable oil.

X Q. 82. And in the barrel it was doubtless clean oil?

A. I should think so.

X Q. 83. When he drew it out of that barrel by a cock, as I think he described it, into a vessel from the storage warehouse, and he carried it, I do not know how far, to his

several sub-stations and put it into these pot-heads where it was exposed to the atmosphere, it would be contaminated [fol. 292] by whatever was floating in the atmosphere, and it became a contaminated oil, did it not?

A. I suppose that you will have to say that it took up some air.

X Q. 84. And with the air it would take dust, would it not?

A. I do not know what the condition of the air was at that point. I wouldn't say the oil was badly contaminated.

X Q. 85. I think you are dodging my question. Now, I said "contaminated", and you say you do not think it was badly contaminated. I am trying to find a reasonable term to describe that oil as distinguished from the oil originally in the sealed barrel, and instead of helping me, I think you are quibbling.

A. I have no desire to quibble with you, that is not my intention.

X Q. 86. Let us try to get together and agree on terms: let us call this oil contaminated, this oil contaminated, even to a slight degree, if you want, but your proposition is that this oil running down into these cables which had dried out made them better than they were before?

A. Yes.

X Q. 87. Now, these witnesses also testified that they found this oil had gotten into cable joints some distance beyond the place where they had been put into the pot-heads, and had dissolved the paraffin in those cable joints. I want to ask you whether that would not seriously diminish the efficiency of those joints as far as their dielectric value was concerned?

A. I do not think so, sir.

X Q. 88. I think you said that in filling these sleeves by the vacuum process the air is exhausted from the tapes, either of paper or of woven fabric, and that the meshes of [fol. 293] these tapes are then receptive to this thin oil if a thin oil is used, did you not?

A. That is right, sir.

X Q. 89. And after the vacuumizing operation the letting of oil into these sleeves will cause the oil to enter the meshes of the fabric?

A. Right, sir.

X Q. 90. And would that be true of varnished cambric?

A. No, sir.

X Q. 91. It wouldn't enter the meshes of varnished cambric?

A. No, sir.

X Q. 92. But anything that was not varnished, the thin oil would enter?

A. I wouldn't say anything.

X Q. 93. Well, anything which is commonly used as a cable wrapping in joints. Do you know anything else than varnished cambric that it would not enter?

A. I suppose I might think of various things.

X Q. 94. I mean anything that is in use.

A. Paper and varnished cambric are the only things that we are discussing here, and oil would not penetrate the varnished cambric. It would penetrate the paper and the white linen tapes that are referred to.

X Q. 95. Doesn't the Vernier article teach you that oil should not be permitted to run out of the joints of the cable into the cable itself to any substantial distance?

A. The Vernier article teaches very definitely that the oil should not be allowed to leave the joint exposed, but it says little or nothing about the passage of oil into the cable for any considerable lengths.

X Q. 96. Now, will you listen to the question again; I do not think you have answered it. I would like to have as near a categorical answer as you can give.

[fol. 294] (X Q. 95 was repated by the reporter.)

The Witness: What was my answer?

(Answer to X Q. 95 was repeated by the reporter.)

The Witness: Was that not an answer?

X Q. 97. It doesn't seem to me you have answered that.

Mr. Usina: Please read the question again.

(X Q. 95 was again repeated by the reporter.)

The Court: As you read this article does it teach you that or not?

The Witness: Your Honor, I think my answer goes about as far as I can go with that.

The Court: All right. If you can't answer yes or no, you have to answer it the other way.

The Witness: Yes.

X Q. 98. You say you can't answer yes or no to my question?

A. No.

X Q. 99. The term "leakage" is used very often in the Vernier article. When we speak of "leakage" in systems of this sort, isn't the word usually a term of reproach?

A. Leakage should usually be avoided, electrically speaking.

X Q. 100. In discussing the question of breathing, in answer to Mr. Neave's question, you quoted from page 350 of the Vernier article (page 188 of defendant's volume) a sentence commencing in the third line of the page, saying that the oil siphoning had been put down to "alternate ex- [fol. 295] pansion and contraction of the cores," and you ended it. The sentence continues, does it not, "but that is new to me, as I have always understood that it is entirely due to a capillary effect of the core insulation."

Did you give your answer?

A. I did not hear the question. You were reading. I didn't understand there was any question involved.

(Last question repeated by the reporter.)

The Witness: The question is the sentence continues?

X Q. 101. Yes.

A. The sentence does continue and say that, and there is considerable discussion throughout here as to just what are the causes of the so-called breathing, what we have called the breathing of the cable, and this gentleman thinks that capillary action comes into it.

X Q. 102. Now, again in the Vernier paper, in the discussion by Mr. Morton, on page 353, you referred there to a part of the text which referred to the cable running warm and expanding and absorbing oil. I want you to read and see if that sentence doesn't end "any air present in the cores taking the place in the box of the excluded oil when the cable cools down"? That is the end of the sentence, is it not?

A. That is the way it reads, yes, sir.

X Q. 103. Does that mean that when the cable cools and contracts it will draw a certain amount of air into it from the box?

A. It means that there will be such a tendency in such a cable as is being referred to there. But we must go back [fol. 296] to Mr. Vernier's discussion of this feature in which he has called attention to the fact that tendencies of that kind usually indicate that the cable is not properly impregnated, and that in the better grades of construction which he says were then available to him he did not anticipate any considerable migration of oil due to any such cause.

X Q. 104. I am really not curious to know just what these gentlemen thought about the causes, but what I am really interested to know in this question is the fact, and I want to ask you when the cable cools down and draws the oil into it, if there were any air in the oil in the joint box, that would remain behind in the joint box, would it not?

A. Probably some would move along with the oil if the oil moved at all.

X Q. 105. Some would move along with it and some would remain back?

A. Yes. If there were air there already, there could be motion into the cable.

X Q. 106. And the air that remains behind would rise to the top of the body of oil, I presume?

A. Yes, it might.

X Q. 107. Don't you think it would?

A. Well, not necessarily, no, sir.

X Q. 108. No?

A. No.

X Q. 109. Air ordinarily rises in oil, does it not?

A. Well, it doesn't rise very rapidly, and it doesn't rise always in the case of these oils we are talking about. In that case the structure of the insulation is fairly compact, and if the oil is fairly dense, then air will remain stationary in rather large bubbles over long periods.

X Q. 110. Suppose we have a body of oil not in fine laminations, but in a substantial body around the wrappings [fol. 297] and that had air in it, that would tend to collect at the top, would it not?

A. Yes.

X Q. 111. I think you said that it was your own opinion that oil of a creamy or vaseline consistency, to which Vernier refers, would flow into his cable to fill the voids therein; did you express that as your opinion?

A. The question as I remember it was that the vaseline having been put into the sleeve and the voids completely impregnated, whether the process would go on, and my answer was that it would, it would be facilitated by the temperature changes resulting from the loading of the cables as well.

X Q. 112. So that in your judgment it would flow into the cable and for a long time to continue to do so, as long as there was any demand for it in the cable?

A. As long as there was any demand for it, yes.

X Q. 113. Doesn't Vernier say that there wouldn't be any such migration into the cable for any substantial distance of oil from the joint-boxes?

A. In the answer to the preceding question I was thinking entirely of the joint; I didn't know that the cable was involved with that at all.

X Q. 114. I do not want you to misunderstand my question. When I speak of cable, I mean the cable beyond the joint. Now I ask you——

A. I was speaking solely of the joint in my proceeding answer.

X Q. 115. And of the portion of the cable that lies within the joint casing?

A. Yes, sir.

X Q. 116. Now let me ask you the further question: With material of the consistency described by Verner of vaseline [fol. 298] or thick cream, would it flow to fill voids in the cable beyond the joint-box, in your opinion?

A. Not if the joint-box were tight.

X Q. 117. You mean even in the use of cable heating and cooling over a period of time, the oil in the joint-box would not flow into the cable beyond the joint-box? I am talking about the Vernier installation, you understand.

A. Yes. If you are talking about the Vernier installation, you must remember that Vernier is talking of vacuum impregnated cables which he is assuming are very tightly filled, and in which there are, therefore, no voids; and he says in his experience he has found very little evidence of

migration of the compounds from his boxes under those circumstances.

X Q. 118. Will you find me where he says that? I think you are mistaken in your quotation, and what he said was he found very little harm from that cause?

A. Yes, that is the intent of what I meant to say.

X Q. 119. If you will find me the particular part you refer to——

A. "Although one hears this objection of oil frequently moving, the author has yet to meet a case where a breakdown has occurred from this cause, and with cables impregnated under vacuum as E. H. T. cables always are the leakage should, in any case, be very small."

X Q. 120. So he doesn't say there hasn't been any such migration or leakage, but he says that it is very small and that he has never had a breakdown from that cause?

A. He was a very experienced engineer and installed a great many cables, and I would take his statement here to [fol. 299] indicate he found very little evidence of migration.

X Q. 121. I should take his statements to facts, Doctor, but what I am interested in is to find out what he did say, because that is what is important, and not what he knew, but what he said in those publications.

You referred in your direct examination to a part of the Vernier article on page 358, and you quoted:

"Anyone who has had experience of the trouble encountered with joints on high-tension cables, * * * will certainly agree with this view," namely, that "the joint filled with soft compound after it has been exhausted by a vacuum pump will become universal for high-pressure systems."

Did you not omit in your quotation this part of that sentence, after "trouble encountered," "with joints on high tension cables, practically all of which is attributable to air or moisture?"

A. Well, if I ended it at any earlier point I only did so because I thought it was the only pertinent thing at that point.

X Q. 122. That answers my second question, but not my first one. Did you intentionally omit that part of the sentence?

A. No, sir.

X Q. 123. I call your attention to the Vernier article, page 327 (page 165 of defendant's volume). I understand from the portion of the first eleven lines of this page that Vernier's idea was to suggest the use of oil in the joint boxes if he could find a way to prevent migration of the oil into the cable a distance beyond the joint. Do you think that that was his idea?

A. Yes, sir.

[fol. 300] X Q. 124. How many joints, Doctor, are described in this Vernier article: "The laying and maintenance of transmission cables," taking all the different combinations and permutations he describes?

A. I think we may say safely, without much possibility of error, take the illustrations as an answer to that question. The illustrations show six joints, and there is very little description of one or two of these, but I take it that all of them must be referred to somewhere.

X Q. 124a. Doesn't he describe the possibility of using two kinds of compound with each of those six joints?

A. Well, certainly not specifically in connection with them.

X Q. 125. Is that so?

A. He refers to a difference in the preferences of different engineers, but I do not think that he seems to suggest that in connection with any one of them, that he didn't choose a particular compound for himself.

X Q. 126. He says, near the top of page 326 (defendant's book 164) "The joints of either type (Figs. 12 and 13) may be filled either with an insulating oil or a joint-box compound (of a solid or viscous nature)." That means either type compound for those two figures at least?

A. Yes, I think he is referring to the practice of the day there.

X Q. 127. Do you find any distinction of the three classes of compound, oil, solid compound and viscous compound?

A. Certainly, those three gradations are mentioned, but I do not think he means to be distinct about them in any way.

X Q. 128. In building these joints you wrap tape about and in between the layers of tape there is compound in films, is there not?

A. In the paper and white linen tape.

[fol. 301] X Q. 129. There is no oil between the layers of varnished cambric?

A. Varnished cambric is very often delivered under oil, and when it is applied as an insulating covering of that kind it is drawn very tight, and all of the oil except perhaps the very thin layers to which you have referred before, is squeezed out. These tapes are very elastic and they fit very tightly, and I do not think that when such a covering is put on a joint, that there is any flow of the oil surrounding the joint through the wall or into the wall or even into the spaces between the layers of varnished cambric.

X Q. 130. You have misunderstood my question.

A. Perhaps so. I did anticipate a bit, because I remembered your discussion yesterday. I beg your pardon.

Mr. Usina: Will you repeat the question to him?

(X Q. 128 was repeated by the reporter, together with the answer, and X Q. 129.)

A. Yes, there may be a very thin oil film between the layers of varnished cambric, but I do not think there will be any motion of that oil or exchange.

Mr. Usina: I object, your Honor. I want an answer to my question without qualification.

The Court: He hasn't gotten so far as to ask for the migration. He wants to know whether there is oil there.

The Witness: Yes, very good, sir.

The Court: The answer is "Yes, there is a slight film of oil?"

The Witness: Yes.

[fol. 302] X Q. 131. Now, this oil which you find in films in the tapes of all sorts, has it a greater dielectric strength than the same oil would have in a continuous body of oil, I mean a greater dielectric strength per unit of thickness?

A. Yes.

X Q. 132. Much greater?

A. Well, I think it might be a considerable amount greater, yes, sir.

X Q. 133. Can you say about what the ratio of dielectric strength would be in the case of a continuous body of oil compared with the same thickness of oil presented in films?

A. No, sir, I couldn't say.

X Q. 134. Is it a thing that is known to electrical engineers?

A. Well, I think that any electrical engineer would hesitate to give a definite figure for a thing of that kind.

X Q. 135. Can you give me an approximate figure?

A. Yes.

X Q. 136. Which you think is reliable?

A. The value might go from 25,000 to 60,000 or 70,000, under certain circumstances.

X Q. 137. You mean 25,000 times as much?

A. Volts per centimeter.

X Q. 138. 25,000 volts per centimeter for the continuous body, and 60,000 for the films?

A. That is fairly close.

X Q. 139. I am trying to get the meaning of your answer. Please do not qualify it. Do you mean that you would have a continuous body of oil with 25,000 volts resistance, and with the same thickness of oil in films you would have 60,000 volts?

A. You might.

X Q. 140. That is approximate, I understand.

On page 218 of the book, the author says: "With air, ionization no doubt takes place with the longer times of application of pressure, but similar results are obtained [fol. 303] with solid insulations." I am not clear as to the meaning there. Does he mean that even if you do not have any air bubbles in the insulation, you will get similar results to those that you get with the air bubbles?

A. I remember to have had some uncertainty myself as to just what the reference was there to solid insulation. I take it in his reference to solid insulation he means that if, under temperature reduction or for other causes, a crack or air opening, an opening containing air, is caused, why, then ionization would take place in them too.

X Q. 141. I call your attention to the Vernier article, page 327 (page 165 of defendant's book), where the author says:

"A joint"—this comes about the middle of the page—"A joint which the author considers more reliable than either of the two types already discussed, and one which, moreover, does not call for such great skill on the part of the jointer, is illustrated in Fig. 15."

X Q. 142. This joint of Fig. 15 does not have any tapes around the joined ends of the cable, does it?

A. No, sir.

Mr. Neave: I offer in evidence a copy of the Torchio patent No. 1,841,320, issued January 12, 1932, on an application filed June 5, 1925, a patent issued to this same Torchio, a later patent.

(Marked Defendant's Exhibit AA in evidence.)

[fol. 304] (Mr. Neave reads a portion of Defendant's Exhibit AA.)

Mr. Usina: May I ask the purpose of the offer?

Mr. Neave: I have just told it.

Mr. Usina: I think it isn't competent what Torchio thought in 1925. It seems to me to have very little bearing on his own construction where an inventor has applied for a second patent ten years apart.

The Court: I know; and the contention of the alleged infringer is that the inventor himself never thought of the scope that you claim for his particular patent. It may be relevant to show that as proof of that, that he thinks it is patentable today as an idea and has applied for it.

Mr. Usina: Well, the patent, of course, is different from that, but if your Honor wants to see it, I have no especial objection.

The Court: As I understand it, there was no discussion here that Mr. Torchio's idea was not workable, but the extent of its workableness, Mr. Neave insisting that it must be confined to the ends of the joint, and he never thought of treating anything else.

Mr. Neave: That is what he says.

Mr. Usina: This second patent is for an even thinner oil, which goes still farther.

The Court: All right. I will give due weight to it.

Mr. Neave: The defendant rests, except that there is a [fol. 305] short stipulation that Mr. Monroe will have arranged with Mr. Usina for the morning.

The Court: Then we will adjourn until tomorrow morning.

Brooklyn, N. Y., April 22, 1932.

Met pursuant to adjournment at 10:30 A. M.; present as before.

Mr. Neave: I have here now a photograph of the test apparatus that was in court yesterday, and I offer it in evidence.

(Marked Defendant's Exhibit V in evidence, in place of Defendant's Exhibit V for identification previously marked.)

Mr. Monroe: If the Court please, Mr. Usina and myself have agreed upon a form of stipulation as to certain facts, subject to verification and correction hereafter.

The stipulation reads as follows:

STIPULATION AS TO CERTAIN FACTS.

It is stipulated as a fact that Thomas E. Murray, owner of the Torchio patent 1,172,322, from June 10, 1922, to February 11, 1927, was a director and a member of the Executive Committee of the Board of Directors of the Brooklyn Edison Company, Inc., from February 24, 1913, to June 27, 1922; and again, from February 24, 1925, to November 27, 1928; and that said Thomas E. Murray was [fol. 306] President of Thomas E. Murray, Inc., a New York corporation, employed by said defendant in a consulting engineering capacity in the construction and equipment of its Hudson Avenue generating station from June 28, 1922, to about February 24, 1925.

ALBERT B. RYBINSKI, called as a witness on behalf of the plaintiff, having been duly sworn, testified as follows:

Direct examination.

By Mr. Usina:

I am employed by the Metropolitan Device Corporation in Brooklyn. I am in charge of production, and a sales engineer for that company. I have charge of the production of electric cable joints for this company. I have been subpœnaed to appear here and bring certain papers with me relating to sales of cable joints in 1924, and have brought those papers.

I recall filling several orders for certain joints for the Public Service Company, in New Jersey in 1926. I have factory records showing the filling of those orders. (Witness hands papers to Mr. Usina.)

These papers show the character of material which was ordered.

Asked what is the name of the company which ordered this material the witness said: There are two names, Public Service Production Company, and Public Service Electric & Gas Company.

I know that those are the companies which provide elec- [fol. 307] tric current in the State of New Jersey. These joints were ordered for various points throughout the State. These orders were filled with the material stated on these factory records.

Asked whether these factory records indicate the design of the joint sleeve which was included in the order the witness stated: The factory order which I hold specifies that they shall be part No. MS55-D cable joints. That identifying number for the cable joint indicates the design of the joint sleeve. It ties in with a drawing which I have here having the same number. The drawing shows a cut-away section of the sleeve after it has been installed with cable on each end and the sleeve made up. And the filling compound and other things that are within the sleeve. The drawing shows all of those.

I know that the units called for by these orders were all made and they were delivered to the customer after the order date. The last completion date marked on the order is February 1, 1927. They were all delivered before that date. A total of 570 units were covered by these orders.

There were four orders on three papers. They all relate to the same thing, they are what we call one job.

Mr. Usina: The orders referred to are offered in evidence.

(Marked Plaintiff's Exhibits 65, 65-A and 65-B in evidence.)

Mr. Usina: The drawing offered by the witness is offered in evidence as Plaintiff's Exhibit 66.

(Marked Plaintiff's Exhibit 66 in evidence.)

[fol. 308] The Witness: Referring to the drawing, Plaintiff's Exhibit 66, I will explain briefly the construction of the joint shown thereon. The joint as shown as No. MS-55-D on drawing No. 3892 consists of a lead sleeve having openings on the two ends and two set-in arrangements

of water-tight filling plugs in the upper part, and having an extended dome-shaped section in its upper central part. Contained in this on the drawing, but made up in the factory as separate units, are a copper mesh sleeve or cylinder, and copper sleeves used for splicing the cables together, certain paper insulation or other insulation used as tape, supplied as tape, and a filling compound which is indicated by the word "metrolatum".

While these parts are shown assembled in the sleeve on the drawing, as I knew them in the factory they were individual parts which were packed up in a single carton unit and shipped out as individual parts.

Asked whether each unit was shipped as a completed assemblage of all the parts necessary for making one joint the witness stated: Assembled in the sense they were all packed in one carton. Packed together, not assembled in operative position.

Asked what was the character of filling compound referred to on the drawing as "metrolatum" the witness said: I do not know anything about its chemical make-up or what it was composed of. My knowledge of it begins and ends here, that it was bought by us on specifications supplied by our customer, came to us from our supplier in sealed cans, completely sealed; and the only knowledge I have of its [fol. 309] nature was gained from the fact that during shipment to us several of these cans were punctured by nails in the packing cases and the material, apparently a light oil or oily substance, ran all over in the packing cases.

Q. 30. Even at ordinary room temperature it ran freely?

A. We never had any other temperature on them except room temperature.

Q. 31. In the drawing there is an enlargement of the upper side of the lead sleeve. Do you know what that was for?

A. That was for the purpose of an oil reservoir in the sleeve, an additional space to hold oil.

Q. 32. Since these were sold have you had any complaint about their operation?

A. None that has come to my attention.

The Court: Wouldn't it come to your attention if there were any made?

The Witness: If there were any complaint with the factory work or anything relating to my work, I would hear about it.

Q. 33. As a sales engineer for the company you would probably have heard of it, would you not, if they had failed in any substantial respect?

A. My duties as a sales engineer take me out occasionally from the factory to the customers to settle some technical phases of the work, and, where, as in this case, we deal directly from the factory to the final customer at a central station, I have had occasion at various times to go over and talk to these people; and, in fact, I have seen some of the installations.

Q. 34. And you have had no complaint about their operation?

A. No.

[fol. 310] The Court: You sold these what year? I missed the year.

The Witness: 1926.

Mr. Usina: The last was early in 1927.

The Court: I see.

Q. 35. And you say that you have seen such installations; do you mean that you have seen them recently?

A. Yes, I saw some of these sleeves in service just a short time ago.

Q. 36. Do you remember that at about the time they filled this order you sent one of the sleeves made in accordance with this drawing, Exhibit 66, to the Brooklyn Edison Company, in an effort to sell them such equipment?

A. I remember having to put through a rush order in the factory for a single sleeve, and remember shipping it to the Brooklyn Edison Company.

Q. 37. How do you know that it was sent to the Brooklyn Edison Company?

A. We put it on our truck with that direction, and our truck delivered it.

Q. 38. Have you ever seen joints being made in manholes, on high tension cables?

A. Not this particular kind of a joint, but I have seen a great many joints made.

Mr. Usina: I would like to introduce as Exhibit 64 a drawing which was marked for identification yesterday, and which I asked the witness as an officer of the Brooklyn Edison Company whether he had ever seen casings of that sort.

(Defendant's Exhibit 64 for identification marked Defendant's Exhibit 64 in evidence.)

[fol. 311] Cross examination.

By Mr. Neave:

X Q. 39. Referring to this drawing, Plaintiff's Exhibit 66, that you have produced, how does one get metrolatum into that joint, into that sleeve?

A. It is poured in through openings in the top of the sleeve.

X Q. 40. The two openings that are shown on the drawing, which are now shown as closed by brass plugs?

A. Yes.

X Q. 41. Poured in hot?

A. I do not know.

The Court: Do you want to look at this? (Handing witness Defendant's Exhibit 66.)

The Witness: Yes.

X Q. 42. Do you know how fluid the metrolatum is when cold?

A. Only so far as I have indicated in my testimony.

X Q. 43. And what was that?

A. That several of these sealed cans were punctured in shipment to us, and that the material those contained was apparently a light body oil, and it ran all over in the packing cases.

I do not know that when you fill the lead sleeve of Exhibit 66 with oil whether it is forced in under pressure. I do not know whether it completely fills the sleeve.

X Q. 46. It could not completely fill the sleeve, could it, the way in which these filling holes are made, that is, they are depressed there and there would necessarily be an air space in the space between the filling holes and on each side?

A. That would seem reasonable.

I was with the Metropolitan Device Corporation in 1927 also.

[fol. 312] I have never seen this particular letter, Defendant's Exhibit S. I can't say that I have seen other letters like that with the same wording in, that went out to possible customers.

X Q. 50. What did you mean by saying you had never seen this particular letter?

A. Well, I have seen a great many letters written by Mr. J. B. Murray to various customers on various subjects.

X Q. 51. And you read them?

A. Yes.

The Court: You recognize his signature, don't you?

The Witness: Yes, I do.

Mr. Neave: That, I am sorry to say, isn't his signature. It purports to be, but isn't, the witness testified yesterday it was not.

The Witness: I think that is correct; I looked at it too hastily.

X Q. 52. This letter I just handed you says, among other things, this:

"A copper gauze stocking, the patented feature, is what distinguishes the metrofatum filled high tension cable joint."

You have seen that statement in letters that have been sent out by the Metropolitan Company?

A. Not that I recollect.

I am familiar with the Metropolitan Device Corporation's advertising matter in 1927 only, in a very general way. If they asked me to work something up for them I worked it up. I have seen a number of these ads, but this particular [fol. 313] one that you have handed me I do not seem to recollect.

Mr. Neave: Will you agree that was put out by the Metropolitan Device Corporation in April, 1927, an advertisement in the Electrical World?

The Witness: It is——

Mr. Neave: No, I am asking Mr. Usina.

Mr. Usina: I believe that is correct; I will agree to it subject to correction if need appear.

Mr. Neave: I offer that in evidence.

The Court: I will take it, subject to, if you find out that it is an error.

Mr. Usina: I object to it as immaterial.

The Court: Yes, overruled.

(Marked Defendant's Exhibit BB in evidence.)

Mr. Neave: Your Honor, this advertisement——

Mr. Usina: Will you identify the advertisement on the record, because we haven't got a copy of it?

Mr. Neave: It is an advertisement, Defendant's Exhibit BB is an advertisement in the Electrical World, Volume 89, No. 16, of April 16, 1927. It contains this statement in the Metropolitan Device Corporation's advertisement:

"The big difference between this and other joints is the electrostatic shield (a Murray patent) supplied only with the Metropolitan joint. This shield distributes equally the electrical stresses through the conductors."

[fol. 314] The Witness: I was with the Metropolitan Device Corporation in 1925.

X Q. 56. Do you recognize this as one of their advertisements?

A. I may have seen the proofs. I cannot recollect exactly.

Mr. Neave: Mr. Usina, will you agree that this is an advertisement of the Metropolitan Device Corporation in the Electrical World, Volume 86, No. 18, of October 31, 1925, subject to correction if the date is wrong?

Mr. Usina: I will agree to this and the other one, that these are advertisements which appeared on the dates under the name of the Metropolitan Device Corporation, but it is understood that I can't stipulate any more than that because I am not sure.

Mr. Neave: That is right.

The Court: And you object to it as immaterial.

Mr. Usina: I object to it as immaterial, the same as I did the other one.

Mr. Neave I offer that in evidence.

The Court: Overrule the objection and give you an exception.

(Marked Defendant's Exhibit CC in evidence.)

The Witness: I first went with the Metropolitan Device Corporation in 1918.

X Q. 58. Was it established prior to that time or was that the time when it was organized?

A. As nearly as I remember, it was organized around 1900—or, I can't say that accurately.

[fol. 315] The Court: Approximately that date?

The Witness: There are two concerns, Metropolitan Engineering Company, and Metropolitan Device Corporation, and there has been some change in the structure, and I do not know just when that occurred.

The Witness: The two are related in some way.

X Q. 60. This advertisement that I have just put in, Defendant's Exhibit, CC, which was an advertisement published in 1925, says that this Metropolitan Device Corporation joint is time-tested, and that "high tension lines in several of the largest cities of the United States are joined with the metrolatum oil filled cable joints and have been for over 15 years—with entire success."

15 years prior to 1925 brings us back to 1910. These joints, Metrolatum oil filled joints, have been put out ever since 1910, have they?

A. I cannot say that.

X Q. 61. Have any of the joints about which you have been testifying this morning in answer to questions by Mr. Usina been sold to those New Jersey companies since 1927?

A. So far as I know, the ones I have testified about were the only dome type joints which have been sold to the New Jersey company since that time.

X Q. 62. Has the Metropolitan Company sold any joints to the New Jersey company since 1926?

A. I would have to look over the records before I could positively answer that.

I limited my last answer to the dome type because we have looked over the records as far as the dome type of [fol. 316] sleeves are concerned.

The dome type sleeve is the type sleeve shown in the drawing that is in evidence here as Plaintiff's Exhibit 66. We have sold none of those since 1926 to the New Jersey companies.

X Q. 66. And have you tried to sell any of them to the New Jersey companies?

A. Well, I am only occasionally in touch with the sales and the advertising department; I do not know.

X Q. 67. Have you kept track of the operation of these joints that were sold to the Jersey Company in 1926? Are they still operating?

A. I only know that none were ever returned to the factory for credit, and I do know of my own knowledge that

at least four of them are still in service on 26,400 volts; and I do know by hearsay that a great many others are still in service throughout the State of New Jersey.

X Q. 68. And you also know that a number of these collapsed in service, don't you?

A. I have been told—I have never seen one that the joints—some of them collapsed to some extent, in which case they went out and pumped oil into the joints again.

X Q. 69. Do you know whether anybody from the Metropolitan Company was over in New Jersey yesterday checking up on the operation of these joints?

A. I was.

That is when I saw these four I speak of. I didn't see any collapsed one at that time. They knocked the cement off one and I looked at it particularly to see if it was collapsed, and it wasn't collapsed.

X Q. 73. Look at the advertisement of 1927 that the Metropolitan Device Corporation inserted in the Electrical [fol. 317] World at that time, that is, Defendant's Exhibit BB, look at the illustration there and tell me whether those joints and sleeves are such as have been sold by the Metropolitan Device Corporation?

A. Yes, they seem to be.

X Q. 74. They are not the same as the others that are shown in Exhibit 66, are they?

A. I do not see any dome type sleeves among them.

X Q. 75. When did the Metropolitan Company first sell what you call the dome type sleeve?

A. Entered on this drawing you will find this statement: "First made for Public Service, Newark, New Jersey." That was written here by the draftsman at the time of the drawing.

These we sold to the Public Service at Newark were the first of the dome type that we sold to anyone and they were sold to the Jersey company in 1926.

Frank N. Waterman, recalled in rebuttal, testified as follows:

Direct examination.

By Mr. Usina:

Q. 192. In the examination of the last witness you may have heard some reference by Mr. Neave to circulars and

advertisements of the Metropolitan Device Corporation saying that their joint contained means to distribute equally the electrical stresses around the conductors in the joint. Do you recall that?

A. Yes.

[fol. 318] There is in the defendant's joint, as disclosed in the Peterson articles to which we have previously referred, such means to distribute equally the electrical stresses around the conductors. Referring to the Peterson articles, I refer to the parts shown on Exhibits 23 which surrounds the tapered insulated ends of the conductors adjacent the two lead sheaths 8. These are marked 14 and are seen to extend in a conical shape from the lead sleeve toward the center of the joint structure, and to be united with the copper strip which surrounds each conductor in this particular cable at 15.

It is seen in section at the left of Exhibit 23 and in elevation at the right.

The sheath which is marked 13 in Figs. 1 and 2 of the Torchio patent has for its function the distribution of the electrical stresses in such a manner as to make them as nearly radial with respect to the conductor itself as possible. When the lead sheath of the cable is cut away to form the joint, as shown in Exhibit 23, where it is seen to have been cut from the center back to the point marked 8, the electrostatic field which formerly would have extended radially outward from the conductors to the copper tape which surrounds them in this instance are compelled to follow lines which are much more nearly parallel to the conductors on the exterior, while with respect to the neutral potential of the conductor system which is physically in the center of the lower figure, that is, it is symmetrical with respect to the three conductors, that neutral has the ground potential, [fol. 319] so that the stresses that arise when the lead sheath is cut away and the copper conductor around each of the—the copper band around each of the conductors is also cut back to the point 15, what I may call the stresses inside the cable become entirely different from the stresses that are outside. The result is to develop circumferential potential gradients around the surface of the conductor from the top to the bottom, and also to some extent longitudinally.

The purpose of the Torchio sleeve or copper gauze sleeve, to distinguish it from the lead sleeve, is to, so far as possible, restore that symmetrical condition destroyed when the cable is cut for splicing.

The defendant has, by wrapping this enlarged section of crotch insulation 13 with lead tape out to the point where the insulation is the thickest, accomplished just that purpose, and has removed stresses which would have tended to cause spark discharges around the surface of the paper and of the varnished cambric; and at the same time it has brought this terminal point sufficiently far from the center of the conductor toward the lead so that no violent disturbance of the uniformity of the electrostatic field takes place in the transition.

The point 14, in other words, and the lead sheath itself, are at the same potential; and by carrying this potential out far enough by the wrapping of the lead tape, 14, the purpose of the Torchio copper mesh sleeve is accomplished to a sufficient extent to produce a substantially uniform field, at any rate, one that is sufficiently uniform for the purposes.

[fol. 320] Q. 195. Then if I may leave out your explanation in detail, is it fair to sum up your answer by saying that the two metal conical wrappings marked 14 in Exhibit 23 of the defendant's joint are substantially the functional equivalent of the gauze sleeve 13 of the Torchio patent?

A. Correct. I have an authority here which shows the nature of compound generally used in joints of this character as late as 1914, the Pender Handbook which I have previously referred to, known as the American Handbook for Electrical Engineers. That is a standard work of authority. It was at the time it was published and still is.

Asked what does it say about the filling material the witness stated; This copy is marked first edition, 5,000, 1914, published by John Wiley & Sons in this country, on page 1930, under the heading "Compounds for Filling Lead Sleeves," it is stated: "A good compound should have a high melting point, adhesiveness, high dielectric strength, low coefficient of contraction, and should not be brittle at ordinary temperatures."

Mr. Usina: I would like to interrupt here just a moment to offer some exhibits which are needed to complete our record.

I offer in evidence the British patent to Price. I cannot lay my hands on it at this moment.

The Court: You may produce it later.

Mr. Neave: Yes, you may produce it later and have it given an exhibit number now.

[fol. 321] The Court: All right.

(Designated Plaintiff's Exhibit 67 in evidence.)

Mr. Usina: I offer a certificate showing the sealing date of the Watson British patent which has been offered in evidence. Those British patents do not show on their face their sealing dates.

This certificate is dated the 24th day of March, 1932, and it says that this patent was sealed as of the 24th of December, 1913, but that the sealing was done——

Mr. Neave: What I want to know is whether you have the publication date.

Mr. Usina: I have not introduced the publication date, only the sealing date. But that states that the patent was granted the 24th of April, 1915, and it was sealed as of the 24th of December. It doesn't show very much.

Mr. Neave: Can we agree it was published February 3, 1915? That was in the Cleveland record, I believe.

Mr. Usina: Doesn't that appear on the face of the patent?

Mr. Neave: Not when it was published.

Mr. Usina: I will agree whatever appears in that record.

Mr. Neave: Then shall we take February 3, 1915, subject to correction if necessary?

Mr. Usina: Yes.

The Court: That is right.

(Marked Plaintiff's Exhibit 68 in evidence.)

[fol. 322] Mr. Usina: The Price patent was offered among an earlier lot of patents, your Honor. We will withdraw the offer, withdraw Exhibit 67. The certificate is 68.

I offer in evidence the Vernier British patent 15413 of 1909.

(Marked Plantiff's Exhibit 69 in evidence.)

Mr. Neave: Wasn't that offered before?

Mr. Usina: There is one Vernier patent in evidence offered by the defendant. I am offering this one to supplement that, and to show that in both of the Vernier patents taken at about the time he published this long article he did not think it worth while to mention fluid compound.

I want to offer two patents of Sachs, copies of patents. The sole purpose is to show certain disclaimers which were sustained by the Circuit Court of Appeals of the Second Circuit in a recent opinion of theirs. They are recent patents. I am offering them merely for reference in my brief to have the exact form of disclaimer.

I offer the Sachs patent 1,292,081.

(Marked Plaintiff's Exhibit 70 in evidence.)

Mr. Usina: And I offer Sachs patent 1,301,175.

(Marked Plaintiff's Exhibit 71 in evidence.)

Q. 201. Mr. Waterman, what is a pot-head for?

A. It is the termination of a cable. It is the very end of the cable, and it is an arrangement whereby the conduc- [fol. 323] tors are taken out for connection to necessary switches and switchboard apparatus, and the like. I do not mean that the conductor ends within the pot-head. They cut back the lead sheath so that the conductors can stick out through, but it is the termination of the lead sheath through which the conductors project so that they are accessible for other connections. There is no joint of the conductors in a pot-head.

Q. 205. Are there any material differences between joints of cables and pot-heads besides the mere fact——

A. I would put it the other way; I do not see any resemblance.

Q. 206. Aside from the fact that there is no connection?

A. I would put it the other way; I do not see that there is any resemblance. It is necessary, to have a cable of any use, that some way of getting the current into it should be provided. For that purpose it is necessary to spread the conductors, and therefore it is necessary in effect to enlarge the lead sheath, and that is what the pot-head does.

Q 207. Do you think a person skilled in the art would reason that what was good in a pot-head must be good in a joint also?

A. Not necessarily. Certainly I wouldn't put it as broadly as that.

Q. 208. Do you think one skilled in the art would reason that if thin oil is a good thing to put into a pot head it would therefore be a good thing to put into a cable joint?

A. Well, certainly not necessarily, because the conditions affecting the installation of a pot head and the conditions affecting the installation of a joint are entirely different. [fol. 324] I see no reason why one should think that the treatment of one would apply in the least to the treatment of the other.

Q. 209. On the question of the passage of oil from a joint such as is shown in the Torchio patent into the cable, I want to ask you first if there were no migration of that oil, how long will you say, as well as you can state it would be before the cable would deteriorate for lack of such oil?

A. A very long period.

Q. 210. Measured in months or weeks or days?

A. Probably years.

Q. 211. Probably years. Is it only necessary for maintaining the cables is good order that the oil from the joint pass very slowly into the cable?

A. Yes, the interchange is very slow indeed. There is no occasion ever for a rapid flow.

Q. 212. You mean that there is no necessity for a rapid flow in order to save the cable from deterioration?

A. Yes, the gradual flow which compensates for the absorption of the cable due to the gradual satisfaction of the absorptive capacity of the insulating materials, of course, is something that takes place over a period of months or years. Then the absorption which occurs as a result of the slow gradual chemical change of the impregnated oil of the cable is also one that takes place over a period of years.

Then there is the breathing of the cable which takes place in accordance with a diurnal cycle, and that calls for the most rapid motion. But as to that the quantity is small, and the time is measured in hours. Therefore the actual rate of migration is exceedingly slow.

[fol. 325] Q. 213. And doesn't need to be fast?

A. No.

Q. 214. In the joint described in the Torchio patent is there any possibility of leakage of air around the screw cap at the top of the reservoir?

A. Of course, there is always such a possibility; a screw cap is never certain of being air tight.

Q. 215. Through the wiped joints where the end of the joint sleeve is soldered to the cable sheath, according to the Torchio patent, is there any liability of leakage there?

A. Yes. I think someone, I think Mr. Woodrow, testified as to that, that such wiped joints are notoriously apt to have pin holes.

Q. 216. I think it has been testified here that oil generally contains a certain quantity of air dissolved in it in minute bubbles, is that your understanding?

A. Yes. The Westinghouse Transil oil at ordinary pressure and temperature, if I remember rightly, takes up a maximum of about 10 per cent. of air by volume, an oil known as Wesco A, I think it is.

Q. 217. In how long a time?

A. Well, at equilibrium. I do not know how long it takes to bring about equilibrium. I do not know.

This air in the oil in a joint such as Torchio describes in his patent, would tend to rise to the top of the oil and accumulate there. Such accumulation would be slow in one sense; it would be reasonably prompt, not instantaneous, of course.

Q. 220. Do these considerations, the possibility of leakage of air around the screw cap, the possibility of leakage of air through the wiped joint, and the air in the oil which [fol. 526] tends to accumulate at the top, do they allow migration into the cable in a joint made in accordance with the Torchio patent?

A. Yes, they assist it. I think it will take place anyway, but they would be of material assistance, of course. A little air would make a material difference in the readiness with which the oil flowed in from an unvented reservoir.

Q. 221. It would flow even without these small quantities of air, but these quantities of air would facilitate its flowing and make it flow a little faster?

A. More readily, take a little less suction to do it.

Q. 222. Mr. Woodrow has testified that if you have a vacuum in the cable and joint as high as 20 inches it would cause the cable to fail on account of ionization, and the inference from that is that Mr. Peterson's statement in the articles by him which have been offered in evidence here is erroneous. I would like to know what you have to say on that point?

A. I do not think Mr. Woodrow's statement as he stated it is correct; it is either meaningless or incorrect. Whether air in a cable or in a joint is going to cause ionization or not depends upon the extent of subdivision. Air in cracks or voids will ionize, and the lower the pressure the more readily it will ionize, but air in minute quantities does not cause, isn't subject to ionization.

Q. 223. You mean in minute separate bubbles?

A. Yes, in small bubbles. It is a well known fact that the carriers which cause the ionization have to have space to get up to ionizing velocity. The Peterson paper, the sec [fol. 327] ond Peterson paper, I note makes that statement at the bottom of page 1031: "On the other hand," he says, "small amounts possibly finely divided will not ionize even under appreciable vacuo at the same gradient." In other words, if the space is small, the voltage before ionization can take place, the voltage gradient before ionization can take place, has to be very large. Therefore, at 20 inches of vacuum, air in minute subdivisions isn't likely to ionize and so minutely distributed it isn't likely to be serious if it does. But when you have a large void that is a wholly different matter, and then I agree with Mr. Woodrow.

Q. 224. Will the cable break down under high vacuum regardless of the size of the air bubbles occluded in the structure?

A. I am not sure that I get the distinction between that question and the preceding one. Of course, high vacuum implies that there is air and that the pressure is reduced. I take it you would not use the term "high vacuum" if you had in mind a space completely filled with something else, as, for example, oil.

Q. 226. Let me change the question, then, instead of a vacuum. Will the cable break down under a high suction caused by a great shrinkage therein, regardless of the size of air bubbles occluded in the structure?

A. Why, no; the question of the effect of air bubbles is predominantly a question of their size. For a given gradient and pressure there is a critical size below which the ionization is not, will not result under the prescribed conditions. That does not say it would not under some other [fol. 328] prescribed condition. But the fact is that finely divided air is not anything like as subject to ionization.

I heard the testimony of Mr. Woodrow about the experiments which he made with the apparatus indicated in Defendant's Exhibits T and V.

Asked whether these two experimental apparatus present any substantial difference, present any substantial difference from each other, the witness stated: No; it is the same experiment in either case; making it in the form of a joint does not make it any different from the little glass bulb affair. It isn't like a joint in either case.

Q. 229. Do these experiments indicate that with the construction of joint shown in the Torchio patent there will be no flow of oil from the joint into the cable?

A. Not the slightest.

Q. 230. Was the lack of any heating and cooling operations in these experiments of any importance?

A. Probably of a good deal of importance, very likely of controlling importance.

Q. 231. Why?

A. Well, I would like to point out, if you do not mind, what I consider to be the lack of analogy here before answering the question specifically.

Q. 232. Lack of analogy to the Torchio apparatus, you mean?

A. To the Torchio joint or defendant's joint.

Q. 233. Very well, please do that.

A. The apparatus of Exhibit T is two chemists' bottles each having a pipe connecting them in the bottom, a stop cock is put into the top of one so that it could be filled, and then connection with the air shut off, and a vacuum pump and gauge taken from the top of the other.

[fol. 329]. Exhibit V is an ordinary joint sleeve with a piece of continuous cable shoved through it in order to afford an easy way of closing the hole in the ends, as I understand it. The lead sheath, as I understood the testimony, is continuous on the cable straight through so that the sleeve is simply an annular container.

To this at one end is attached a rigid reservoir with a small standpipe at the top and a petcock so that it could be filled, and the absence of any air insured.

The joint opening, joint sleeve opening in Exhibit V, which is at the other end, is connected by rubber tube and an appropriate fitting to the pump. It does not appear in either case how the filling of the member that is supposed

to act as a reservoir was accomplished, but the natural way of accomplishing it with the apparatus shown would be to apply a suction at the top of the reservoir and pull oil up in and then turn off the cock, and I assume that that was the way it was done. The suction was applied to the suction end of the apparatus in either case.

There was no cable joint inside the sleeve or anything analogous inside of the glass tube in Exhibit T. The powerful slow capillary pull that the insulation exerts had no counterpart whatsoever in this apparatus, nor is there anything in the cable that is the counterpart of a suction applied by a pump above a body of liquid.

The vacuum pump was applied in each case to a container space, or at any rate, a pipe space above the liquid level, and the pump operated the first question arises why the [fol. 330] pump did not at once show a high vacuum instead of showing 5 pounds, 10 ponds, 15 pounds, 20 pounds, why didn't it at once show a high vacuum? Naturally, because it took some time to pump the air out of the oil so that the oil here was completely deprived of air and gas while the experiment was continuing. Having a low head, due to oil reservoir level the vacuum could work up to 26 inches, before anything more than a very small quantity of oil seeped out, in a hurried experiment.

The pull of the capillary action of the cable insulation would, however, pull the oil from the sleeve into the cable, exposing the end of the reservoir, which spaced above the lowered level would have air at some pressure. The operation of the reservoir then is precisely like the operation of the water bottle in the cooler. It is carried on at a low pressure, but it goes on in the same way.

Mr. Peterson, in the section of the article, which is Exhibit 22, points out that when these bellows type reservoirs were applied to the defendant's system in 1924 it was found, on subsequent inspection that "many of the reservoirs were entirely devoid of oil; others contained large voids."

Now, of course, this collapsible reservoir, when it is collapsed to the limit, becomes essentially a solid reservoir, and notwithstanding that fact the reservoirs were found entirely devoid of oil or contained large voids. That is, air spaces.

Well, of course, that at once is evidence of the travel of the air from the cable into the sleeve, from the oil in the

sleeve and in the cable into the sleeve; and by its water [fol. 331] bottle action, I have just referred to, it rises up into the reservoir as the oil passes out. Then the collapsing of the joints that has been referred to a number of times is, of course, a most positive proof of the migration of oil out of a perfectly tightly sealed joint or at least as perfectly tightly sealed as joints are, and the creation of such a low vacuum inside that the air pressure on the outside crushed the sleeve, showing again that under the influence of the capillary pull and the slow action of a cable, oil will flow, and we do not have to be told this for we know that if we fill a bottle full of oil, without any air in it, and we carefully invert it in the usual manner with a paper cover, oil will not come out at the moment, but we can rub our finger across the bottom and take out oil indefinitely through capillary action. Of course, the capillary action is notoriously powerful.

Very likely your Honor was taught, as I was in my school days in elementary physics, how the ancients used to split stone for their obelisks and the like by drilling holes in the stone, and driving a dry plug of wood in each, and then dripping water on the wooden plugs. The capillary action takes the water into the plugs and swells them and splits the stone.

Capillary action is a very powerful force given time, and it has all the time it needs in the cables. It accomplished what the experiment performed by Mr. Woodrow, which has no likeness to the cable joint at all, did not accomplish.

Q. 234. In a joint of Torchio's, as shown, would the movement of the expansion and contraction of the oil have [fol. 332] any effect to assist the pulling of the oil out of the reservoir?

A. Yes, undoubtedly the circulation which is due to the change of the temperature, therefore causing continued circulation of oil in the joint, would assist both in supplying oil to the cable and taking it from the reservoir; and further, of course, it would assist in the disengagement of the air and other gases that are dissolved in the oil. There is not only air, but other gases. I have seen published analyses—I have not them at hand—showing the nature of the gases that can be pumped out of the oil; and air is included and there are other gases.

The Witness: In the Vernier paper that was testified to by Dr. Whitehead yesterday, which is a part of the book, Defendant's Exhibit Z, I do not find therein any description of a cable joint like that of the Torchio patent.

The teaching of the Vernier article as I read the article is not that the joints in cables should be such as to permit a flow of the filling compound into the cable. The teaching is quite the reverse.

Q. 238. Does this article of Vernier teach that air will pass or gases occluded in the cables will pass from the cable to the joint?

A. It does indicate that they will pass from the cable to the joint. That is regarded as an evil, and ways of preventing it are suggested.

Q. 239. Does it teach that the cable and the joint breathe?

A. Not at all.

Q. 240. Does it indicate any idea to take advantage of the variations in temperature of the cable during use?

[fol. 335] A. So far as the impregnation of the wrappings on the conductors in the joints, yes. In the middle of page 326.

Q. 241. Read me what it says on that point.

A. This is referring to Fig. 12, which is the first type of joint described, namely, the one in which wrappings are placed around the conductors where spliced. It says:

"The cores should also be separated at intervals by similar bands of insulating tape, so as to allow the greatest possible freedom of access to the oil, which will keep the insulated tapes constantly impregnated, and this will be greatly assisted by the contant temperature changes which the cable undergoes under changes of load."

That statement was referred to by Dr. Whitehead as showing a disclosure of breathing.

Q. 242. Do you find that it corresponds with what the Torchio patent refers to as "breathing"?

A. Not in the slightest.

Q. 243. What difference do you find?

A. The distinction that I was making is that what the article does say at that point is that the temperature changes will facilitate the circulation of the oil in the joint sleeve, and thereby the impregnation of the tapes that have been wound on to it, wound on to insulate the conductors.

Q. 244. You have said that the teaching of the Vernier article is that the flow of compound from the joint into the cable is disadvantageous and should be prevented. Will you point out particularly the part of the article which teaches that?.

[fol. 334] A. Perhaps a more accurate way of expressing what I intended to say would be to say that it teaches that air in the cable should not come out to be replaced by oil.

The author states on page 326, I think the first time it is referred to, that "Oil is objected to by many engineers, who fear its being ab*ab*sorbed by the cores of the cables, and who therefore insist on a joint box compound being used"

Interjecting a word of explanation, the distinction between the compound and the oil is that the oil might flow up the cable while the compound would not, continues:

"Although one hears this absorption of oil frequently mentioned, the author has yet to meet a case where a breakdown has occurred from this cause, and with cables impregnated under vacuum, as E. H. T. cables always are, the leakage should, in any case, be very small."

This means that when the extra high tension cables are manufactured they are impregnated with the assistance of a vacuum; that is, they are put into a vacuum chamber, and the air pressure reduced to a low limit and held for a suitable length of time, and then oil is admitted, and then finally, after complete immersion, air pressure is allowed to come on top so that the air pressure is effective in assisting the oil into the cable, and he says that in such a cable the leakage should be small anyway, and there should not be any occasion for oil flowing into the cable, and he has never encountered any trouble of the sort.

That has to do with the Fig. 12 type of joint. Then he comes to the Fig. 13 type. The difference, as your Honor [fol. 335] will remember, is that in Fig. 12 the conductors are spread apart, joined by a soldered connection of some kind, and then individually taped; then drawn close together. That is, the taped joints are drawn close together and belted; belted, of course, with tape. Fig. 13, however, has the lead cut back, and the cables separated, the conductors separated and joined as before, and then no insulation

put over the connecter at all, but spreaders, porcelain spreaders, put in to keep the conductors sufficiently separated from one another; and then the joint compound put in.

Now, as to that, he says on page 326:

"It has been found, however, that there is always a certain amount of air present in the cores and insulation of the cables, due to the impregnating oils of the cables running out when the cable is cut, and also being dried out by the heat in soldering the joints. The net result of this is that the hole due to shrinkage always forms at the ends of the cores and draws out air from the cores. This air pocket causes breakdowns of the joints due to sparking which takes place from core to core across this air space."

Now, instead of suggesting that the compound should flow in to fill up the space left by that which he says flowed out, he says:

"By insulating the cores separately with insulating tapes before the joint compound is run in, this drawing out of [fol. 336] the air from the cores can be avoided."

In other words, he says, "Put on tape insulation and shut the air in—do not let it get out and then put in a compound."

He continues; I did not really finish the sentence before. He says:

"This drawing out of air from the cores can be avoided and breakdowns from this cause prevented."

But he says that the objection to having the tapes on there to hold the air in is that you will then have oil-soaked tapes, oil-impregnated tapes surrounded by harder compounds, and he says that he does not approve of that, and for this reason he recommends oil; that is to say, after you have taped the cores, the conductors, so as not to let the air get out of the cables, then you should fill with oil; but he says:

"It is again objected that it may leak out up the core of the cable, and on this account in a joint of this type the author prefers that the core should not be taped over, and that a viscous joint-box compound be used which never sets and in which cavities cannot form."

In other words, again he proposes to use a compound that will shut the air into the cable.

Neither of the joints that are here described, as shown in Figs. 12 and 13 are joints that the author recommends. [fol. 337] The joint that he prefers is that of Figs. 15, 16, 17 and 18; and that is one having Micanite separators, mechanically different from, but electrically similar to the Conduceli separators which Mr. Woodrow, I think it was, testified were not successful; and in that case he put no wrapping of insulation on the joint conductors, but he slips these Micanite tubes over them, fitting very loosely, as the figures show; and then again he uses the preferably viscous joint-box compound.

The teaching of the Vernier paper is fairly illustrated by these quotations, but throughout I do not find anything that would teach one to supply oil to a joint in order that it may freely flow into and impregnate a cable, and to keep it supplied. The idea of keeping it supplied is not there at all. There is no suggestion of a reservoir, nor is there any suggestion even that the bleeding occurring in the active bending should be made good, and certainly there is no suggestion of the cyclical breathing and flow that Torchio refers to, and which is also made clear in the Peterson articles.

Mr. Usina: I do not think that the Vernier articles need any more explanation, your Honor. The rest of it is quite clear, and I am going to pass that now.

Q. 245. I have made a sketch to illustrate what I understand to be the construction of the pothead described by some witnesses from Baltimore in accordance with Defendant's Exhibit A; and I ask you if that is your understand- [fol. 338] ing of the structure inside the pot-head? (Handing to witness.)

A. Yes.

Q. 246. Will you please mark on that the cable itself, the lead sheath of it, the conductors, and the wrapping around the conductors, and give them reference letters and explain them briefly?

A. I indicate the cable collectively by "C"; the lead sheath of the cable as "S"; the three conductors at "1", "2", "3". The bell as "B"; the lid as "L"; the insulat-

ing tubes through which the conductors are supposed to pass as "T".

Mr. Usina: I offer this in evidence and ask leave to substitute a drawing in ink for it.

(Marked Plaintiff's Exhibit 72 in evidence.)

Cross-examination.

By Mr. Neave:

X Q. 247. I suppose it is true that air in solution in oil is not in the form of bubbles and does not appear as bubbles, until the pressure is very low.

A. That is true.

X Q. 248. Is it not true that air in any subdivision, even the smallest is subject to ionization?

A. If the pressure gradient is enough, yes, sir.

X Q. 249. What do you mean by that "gradient"?

A. If the voltage available on an ion or electron to set it in motion is sufficient, the ionization will occur in quite small spaces. If you want an exact discussion of the critical distances, you will have to give me time to look it up, because I do not remember it. But that is a well-[fol. 339] recognized fact, that in air in fine subdivision ionization takes place only with great difficulty.

X Q. 250. If the pressure in the cable is low, that relieves the pressure on the air bubbles and increases the danger of ionization, does it not?

A. Everything else being equal, yes.

X Q. 251. If the joint-box, as shown in the Vernier article, is filled with a light oil or a viscous oily compound which never sets, will not the oil or viscous compound impregnate the pervious wrapping in the joint-box and in the cable the same as in the Torchio patent?

A. It is a little difficult to answer that question. Vernier clearly contemplates the application of wrappings which will prevent the interchange of air between the cable and the joint; by the same token I understand he means to prevent the interchange of oil between the cable and joint.

X Q. 252. But——

A. On that point the answer to your question is "No".

X Q. 253. I beg your pardon.

A. I was going to give you the other branch of the question. The other branch of its application to Vernier, Vernier seems to contemplate a joint-box compound that can be relied upon to prevent the passage of air from the cable into the sleeve; and per contra, as I understand him, it will stay in the sleeve as distinguished from going into the cable. That is what I regard as his teaching.

Now, as to what will happen in a given case, I have got to know the construction.

[fol. 3404] X Q. 254. Got to know what?

A. Got to know the construction and materials.

X Q. 255. Let us suppose you have a joint-box that has a joint that has on it pervious paper wrappings, pervious to oil, and suppose that joint-box is filled with oil, the oil will permeate into the paper wrappings if they become dry, will it not?

A. I think so.

X Q. 256. That is true if you have a viscous oily compound that never sets; that will also permeate, will it not?

A. I think that is too general.

X Q. 257. Why is it too general? Do you want to know something more about the paper or something more about the viscous compound that never sets?

A. The viscous compound that Vernier is talking about is quite heavy, and correspondingly, something that will not migrate.

X Q. 258. All right. Never mind. I am not trying to get to his theory.

The viscous oily compound or insulating compound that never sets always is absorbed in the paper if the paper is pervious?

A. If it is that kind of compound, yes.

X Q. 259. Do you know of any viscous oily compound that will not be taken up by the paper?

A. By "taken up" do you mean the sense of migration into a cable?

X Q. 260. No, I mean will it not permeate the paper, the paper wrapping?

The Court: Absorb.

A. The paper will certainly absorb.

X Q. 261. Yes.

A. It will become greasy.

X Q. 262. I beg pardon?

A. The paper will become greasy from anything that I [fol. 341] know of that could be called a viscous oily compound.

X Q. 263. It would not only become greasy on the surface of the paper but the stuff would get in the paper?

A. Yes.

X Q. 264. Sticking into the ends of the joint-box are the ends of the cable from which the lead sheath has been removed, and the paper wrappings of the cable are exposed, are they not, in the joint-box?

A. Yes.

X Q. 265. That will take up this oil, this viscous oily substance?

A. Unless it is prevented, yes.

X Q. 266. Now, suppose we take the joint of Vernier's Fig. 13, which, as he shows it there, does not have a wrapping on the portion where the connection of the conductors is made, but on each side of that point there are the paper cable wrappings, are there not?

A. Yes.

X Q. 267. If you have oil or a viscous material that never sets filling that joint sleeve, that will be absorbed by the paper wrapping on the ends of the cable that are exposed in the sleeve, will it not?

A. If nothing is done to prevent it, I should say so, yes.

X Q. 268. Now, let us suppose in that same joint-box you take some paper and you wrap it around the exposed portions of the connecters that are connecting the cable conductors together, the oil or the viscous material that never sets will permeate that paper, will it not? That paper wrapping? Be taken up by it and make it oily?

A. Well, if it is that kind of compound, as I say, of course, it will, but you do not have to make the assumption. If it will, it will.

X Q. 269. If it will, it will?

A. Yes.

[fol. 342] X Q. 270. But you do not know of any viscous oily compound that will not, do you?

A. No, I do not think I do, but then the viscous might mean so many things that I do not think that is a fair statement.

X-Q. 271. Vaseline, as we usually see it, is viscous, is it not?

A. Yes, I should think so.

Mr. Neave: Mr. Usina, will you look at this while I read something? Mr. Waterman read a paragraph or two paragraphs of page 1930 of Pender's American Handbook for Electrical Engineers. May we agree that that handbook was published in 1914?

Mr. Usina: Yes.

Mr. Neave: On the preceding page from which I read, page 1929, occurs the following paragraph:

"English Practice. A type of joint used largely in England for multiple conductor cables, has the conductors separated from one another by an insulating spreader or separator, which may be of ebonite, china, or similar material. The shrinkage of the solid compound gives rise to air holes near the conductors with consequent low dielectric strength. By insulating the cores separately with insulating tapes before the conductor is run in, this trouble can be avoided. But it is better to use a viscous compound which never sets (Vernier). This type of joint has two serious defects, first, [fol. 343] breakdown is likely to occur on account of the defects of the separators or on account of moisture on their surfaces; and, the longitudinal pull of the cable such as likely to arise when the cable shrinks in cold weather, puts the separators in compression and may stress them unduly."

Mr. Usina, will you agree that that occurs in the publication?

Mr. Usina: Yes.

HARRY R. WOODROW, recalled in sur-rebuttal, testified as follows:

Direct examination.

By Mr. Neave:

Q. 449. Mr. Woodrow, Mr. Waterman just now, in speaking of your test that you testified to yesterday with the apparatus of which a photograph has been offered in evidence as Exhibit V, said that he could not understand how it was that you could get and observe vacuum of 5, 10, 15 and 20,

and so forth, pounds, but he did think that it would have run at once to a high vacuum as I understood him. Did you observe those various intermediary vacua, and why was it that you did not get a complete vacuum? What was if that you did?

Mr. Usina: I do not think Mr. Waterman said that.

[fol. 344] Mr. Neave: May I ask him off the record?

(Discussion off the record.)

Q. [illegible]. Mr. Waterman did not say he did not understand how that could happen, but he said that the question arose in his mind as to why you did not get the whole vacuum all at once. Why did you not?

A. We raised the vacuum slowly in order to determine the various points at which the levels might be affected.

Our method of making that determination was the connection from the joint, through a bottle to the vacuum pump, and that bottle was put in with air in order to control the pressure at the various points.

In other words, it would have an equalizing volume in the connection from the joint to the vacuum pump; and that would make it possible to maintain it.

The Court: As I understood, Mr. Waterman's explanation was that the reason you had these jumps was because you were getting the air out of the oil.

Mr. Neave: Mr. Waterman said if there was not any air there.

The Court: That is the way I understood his explanation. It was out of these jumps.

The Witness: Do you want that explained?

The Court: Yes.

The Witness: The air in the oil was very small indeed. [fol. 345] We tried to make this as nearly like the joints of Mr. Torchio's as possible. The oil was in the filling of the joints, if you recall his general papers, and then we had it, of course, also under a vacuum filling process. We did the same thing here, put a vacuum on it and maintain a vacuum on the oil, and whatever air would come out of the oil under those vacuum conditions was previously taken out, in exactly the same manner as would occur in the joint made by Mr. Torchio; so that there could not be any air brought out from the oil.

Q. 451. Mr. Rypinski this morning testified as to some domed joint-boxes that the Metropolitan Device Corporation in 1926 sold to some of the New Jersey companies. There was put in evidence a drawing of that domed joint-box. When did a domed joint-box first come to your attention?

Mr. Usina: I beg pardon?

A. In 19——

Mr. Usina (continuing): This is not proper sur-rebuttal, if your Honor please.

The Court: I hardly think you can reopen it.

Mr. Neave: He has put in evidence a drawing of the domed joint-box which had not come in before; and I want to show that in 1914 this witness had before him and Torchio had before him exactly that same domed joint-box.

[fol. 346] Mr. Usina: The only purpose of that offer was to meet testimony which the defendant had produced attacking the operativeness of the Torchio patent.

The Court: That is what I understood it to be.

Mr. Usina: I do not think it requires any sur-rebuttal or permits any.

Mr. Neave: Let me suggest that that domed joint-box, a drawing of which was put in evidence this morning, shows a different thing from anything that has been in evidence before. It is not the shape of the box shown in the Torchio patent. This is the first time that that has appeared; and if they wish to get the benefit of Torchio, as they must, or else they would not have put that in evidence——

The Court: I cannot see what harm it will do.

Mr. Neave: I want to show that——

The Court: To show that it was the drawing that came to the attention of this witness.

Mr. Usina: Or one of the drawings that has been put in evidence.

Mr. Neave: No, it is not.

Mr. Usina: Do you mean these things? I do not think that is proper now. Your Honor, I will have to find out whether I can meet this evidence now. It might be hard. I do not know what it is. I have not the faintest idea what it is, but I do not think it is fair that Mr. Neave should be permitted to reopen his defense this morning.

[fol. 347] Mr. Neave: That came up only this morning in their testimony.

Mr. Usina: Well, of course, but the purpose of it was only to rebut testimony that had been offered by the defendant, which the plaintiff has a right to do.

The Court: I thought you were introducing that on the theory that Mr. Neave urged, that your apparatus was workable within a certain limit, but was not workable beyond that.

Mr. Usina: Yes, sir; that is about what it was for.

The Court: And you wanted to show that having removed the high tension wires he had not only used it, but used it with the tube.

Mr. Usina: Yes.

Mr. Neave: The point is, "used it."

The Court: Used this.

Mr. Neave: "It" is the thing. That is not shown in the Torchio patent.

Mr. Usina: We shall argue that it is the same thing.

Mr. Neave: You can see in the drawing it is not the same shaped joint.

The Court: The same assembly of the elements functioning in the way in which Torchio claims his invention discloses it.

Mr. Neave: We brought that out on cross-examination of this witness, that there would necessarily be an air space on the top of this domed joint. That is not true of Torchio.

The Court: You want to show that Torchio had a drawing before him with a dome on it?

[fol. 348] Mr. Neave: Yes; and here it is.

The Court: I will allow you to do that, but not beyond that. That is all. In other words, we are not going to reopen the case.

Mr. Neave: No. This is the point, that is all.

The Court: I will allow you to show what he had before him.

Mr. Neave: Now, we have to go back and see what the question is, I think.

The Court: Why not ask him again?

Mr. Neave: All right, I will ask him again.

Q. 452. Do you remember that domed joint-box that was testified to this morning?

A. Yes.

Q. 453. Did you and Torchio at any time have before you a drawing showing a domed joint-box?

A. Yes.

Q. 454. Of a similar character?

A. Yes.

The Court: Prior to 1915, was it not?

Mr. Neave: Yes.

Q. 455. And when was that?

A. Yes. It was in 1914. I believe I included that in my testimony yesterday; and Mr. Usina asked me if I had any records of it, which I looked over to see, and this is the record that I was sure there was one in the files some place, so I found this one which I referred to on yesterday's testimony.

Q. 456. What is that drawing, yours or somebody else's?

A. No, this is a drawing of the British Insulated Wire and Helsby Company, dated 1913, 20th of June, 1913. It [fol. 349] came to our attention in the fall of 1914.

The Court: When you say "ours," you mean Mr. Torchio's and your own?

The Witness: I do.

Q. 457. And that is the same old drawing that you saw then?

A. It is the same drawing that I saw at that time.

Q. 458. That drawing does not show a lead sleeve, does it?

Mr. Usina: I object to that.

The Court: Yes. I will allow just the drawing.

Q. 459. All right; never mind.

A. It shows for itself.

Mr. Neave: I will offer that in evidence.

(Marked Defendant's Exhibit D D in evidence.)

[fols. 350 & 350a] In United States District Court, Eastern District of New York

[Title omitted]

Order Approving Narrative Statement of the Evidence

It appearing that Plaintiff-Appellant herein has duly complied with the provisions of Rule 75 of the Equity Rules

of the Supreme Court of the United States with respect to reduction and preparation of the record on appeal herein, I, Robert A. Inch, one of the Judges of the United States District Court for the Eastern District of New York, who tried the above case on final hearing, do hereby certify:

That the statement of the evidence hereto attached, including the exhibits identified in the praecipe of the plaintiff and defendant, and the statement of the testimony part in narrative form and part in the exact words of the witnesses, is true, complete and properly prepared.

Robert A. Inch, United States District Judge.

Dated November 14, 1932.

Record approved and entry of foregoing order consented to.

Usina & Rauber, Attorneys for Plaintiff. Monroe & Byrne, Attorneys for Defendant.

PLAINTIFF'S EXHIBIT No. 1

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P. TORCHIO.

PROTECTIVE DEVICE FOR ELECTRIC CABLE JOINTS.

APPLICATION FILED MAR. 13, 1915.

1,172,322. Patented Feb. 22, 1916.

Fig. 1.

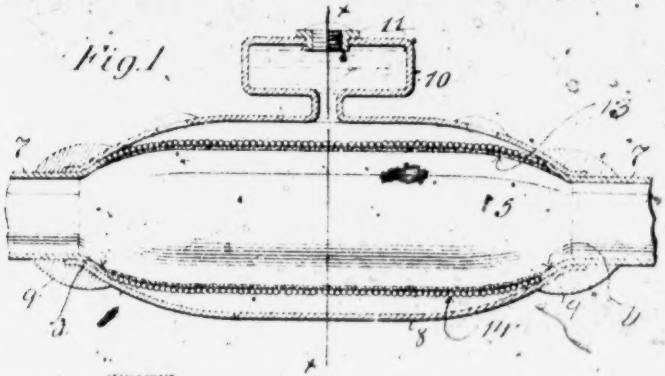


Fig. 2.

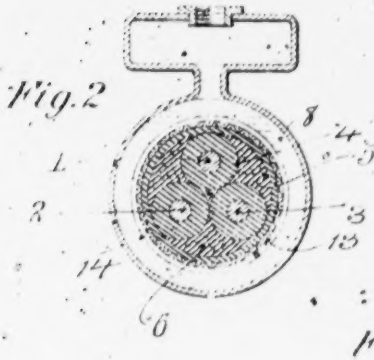


Fig. 3.

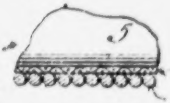


Fig. 4.

Fig. 5.

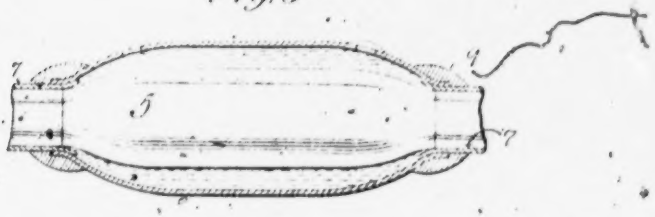
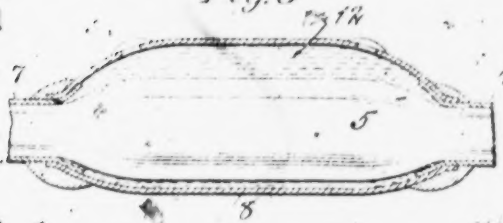


Fig. 6.



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By his Attorney
Paul Synnestvedt

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UNITED STATES PATENT OFFICE.

PHILIP TORCHIO, OF NEW YORK, N. Y.

PROTECTIVE DEVICE FOR ELECTRIC-CABLE JOINTS.

1,172,322. Specification of Letters Patent. Patented Feb. 22, 1916

Application filed March 13, 1915. Serial No. 14,078.

To all whom it may concern:

Be it known that I, PHILIP TORCHIO, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented a certain new and useful Improvement in Protective Devices for Electric-Cable Joints, of which the following is a specification.

This invention is a device for preventing current leakage at a joint in an electric line conductor, and more particularly at the joints in the line conductors of cables.

The invention consists in the construction whereby the joint is immersed in a fluid insulating medium adapted to permeate the pervious wrapping of the joint, whereby said fluid after permeation of said wrapping is retained therein by a denser body of insulating material surrounding said wrapping, and whereby the joint is inclosed in two metallic sleeves united at their ends to one another, separated between said ends and electrically connected at said ends to the cable sheath, whereby the potential on the said sleeves becomes that of the sheath and breaking down of insulation between said sleeve or ionization of air between them is prevented.

In the accompanying drawings—Figure 1 is a longitudinal section of my joint. Fig. 2 is a transverse section on the line *x*, *x* of Fig. 1. Fig. 3 is an enlarged longitudinal section of a portion of the joint insulation, wire gauze cover and twine wrapping. Fig. 4 is an enlarged transverse section of the same. Fig. 5 is a modified form of my device in which the wire gauze cover, twine wrapping and oil supply reservoir are omitted. Fig. 6 is a modified form of my device in which the wire gauze cover and twine wrapping are omitted and the oil reservoir changed in form.

Similar numbers of reference indicate like parts.

My device is here shown applied to a cable containing a plurality of conductors 1, 2, 3, Fig. 2, each having the usual cover 4 of insulating tape and all inclosed in an outer insulating wrapping 5, the interstices being filled with jute, paper or other pervious insulating material 6. In the ordinary operation of making the joint, the lead sheath 7 of the cable is cut away for a sufficient distance to expose the conductors and permit application of the wrappings, and afterward a lead sleeve 8 is placed over the joint and connected by wiped solder 9 to the ends of the lead sheathing, thus hermetically inclosing the joint. Through two holes left in the sleeve 8 a fluid insulating compound adapted to permeate the interstices in the insulating wrappings and filling of the joint is poured. I have found that said fluid compounds do not operate efficiently. In some of them—as, for example, paraffin—voids or openings are formed, due to the contraction of the material on cooling and hardening. In others, because of their quick cooling and hardening, due to contact with the cold insulation, the fluid fails to permeate the wrapping and filling. In almost all of them, the insulating liquid if rendered fluid by heat causes a deterioration of said insulation at the point where said fluid first meets said insulation. In all of them, the insulating compound on hardening will crack under mechanical stresses, especially when the conductors carry heavy overload currents. The consequence is that, by reason of these cracks and voids and the ionization of air in them, a lowering of dielectric strength of the joint insulation takes place, so that electric lines transmitting high tension currents, especially if underground, have their weakest places at the joints and at the ends of the sheathing 7 where connected to the joint covering sleeve 8.

I have succeeded in overcoming the foregoing difficulty by the following means: In Fig. 1 of I show the usual lead covering sleeve 8, provided on its upper side with a reservoir 10 closed by a screw plug 11. I fill the sleeve and reservoir with any suitable insulating oil or other liquid which is fluid at low temperature and preferably of a character which will combine with the material used in the body of the cable for permeating or embedding the insulating wrappings. This liquid I preferably force into the sleeve 8 under pressure sufficient to drive it into the interstices of the cable ends and into the joint wrappings and fillings. When the introduction of the liquid is complete, I permit it to fill the reservoir 10, which is finally closed. The oil in the reservoir then serves to supply any deficiency in the sleeve caused by absorption and breathing of the cable or the disturbance of the conductors carrying sudden overload currents, so that the joint insulation is not only thoroughly permeated at the outset, but continues submerged in a bath of insulating oil.

Instead of making the reservoir 10 in the form of a separate chamber communicating with the sleeve, as shown in Fig. 1, I may dispose the sleeve eccentrically on the joint, so that the greatest clearance will be uppermost, as shown at 12 in Fig. 6. In this way, I produce an additional holding space for the oil within the sleeve itself.

Where for any reason it is not desirable to keep the sleeve filled with a light fluid, such as oil, I may first cause the wrappings and filling of the joint to be permeated with said light fluid, as already described, and then afterward draw off the surplus liquid and substitute therefor an insulating compound of greater density than said liquid to fill the space between the joint and the sleeve. The dense compound then acts both as an insulator and as a means of imprisoning the lighter fluid already in the interstices of the filling and wrappings of the joint.

In order still more effectually to prevent any failure of dielectric strength at the joint, I prefer to inclose the joint wrapping 5 in an envelop 13 of wire gauze, which is electrically connected at its ends *a*, *b* to the cut extremities of the lead sheathing on each side of the joint, so that there is a free conducting path between said sheathing extremities through said envelop. This wire gauze envelop, while permitting free access of liquid into the joint, has the same (ground) potential of the lead sheath. Hence there can be no breaking down of the insulation between the gauze envelop and sleeve 8 even if cracks or voids happen to be formed therein. The gauze envelop can be secured in place by any suitable means—such as a permeable wrapping 14 of tape or twine. I may use this gauze envelop in conjunction with a fluid permeated joint and with fluid between joint and sleeve, as shown in Fig. 1, or with a fluid permeated joint and the annular space surrounding said joint filled with denser insulating compound, as described, or with a fluid permeated joint and simply an air space between joint and sleeve.

It is to be observed that the insulating fluid not only permeates the wrappings and fillings at the joint, but also percolates into the insulation of the cable ends exposed in order to make the joint. This is of practical importance, because it often happens that during the making of the joint, the exposure of said ends permits of the permeating liquid used in the original manufacture of the cable to "bleed" or run out, and a consequent failure of insulation at these points ensues. This I have found to be the cause of breakdowns which were apparently unaccountable. The new fluid put into the joint sleeve supplies this loss and effectually prevents the difficulty.

I claim:

1. An electric cable, comprising a metallic sheath and a line conductor having a joint, the said sheath being removed sufficiently to expose said joint, and two metallic sleeves disposed one within the other and inclosing said joint: the said sleeves being insulated from said joint, united at their ends to one another, separated between said ends, and electrically connected at said ends to said sheath.

2. An electric cable, comprising a metallic sheath and a line conductor having a joint, the said sheath being removed sufficiently to expose said joint, and two metallic sleeves disposed one within the other and inclosing said joint, and an insulating body interposed between said sleeves: the said sleeves being insulated from said joint, united at their ends to one another, separated between said ends, and electrically connected to said sheath.

3. An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, inclosing the same and hermetically united at its ends to said cable sheath, and an insulating fluid adapted to permeate said pervious body contained in the space between said body and said sleeve.

4. An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, inclosing the same and hermetically united at its ends to said cable sheath, a receptacle communicating with the interior of said sleeve, and an insulating fluid adapted to permeate said pervious body contained in said receptacle and the space between said body and said sleeve.

5. An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material, of greater diameter than said body, inclosing the same and hermetically united at its ends to said cable sheath, an insulating fluid permeating said pervious body, and a mass of insulating material of greater density than said fluid contained in the space between said body and said sleeve.

6. An electric cable, comprising a metallic sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, an envelop of foraminated

conducting material inclosing said body, the said sheath being removed for a sufficient distance to expose said envelop, and the said envelop being electrically connected at its ends to said sheath, a sleeve of greater diameter than said envelop, inclosing the same and hermetically united at its ends to said sheath, and an insulating fluid adapted to permeate said pervious body contained in the space between said envelop and said sleeve.

7. An electric cable, comprising a metallic sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, an envelop of foraminated conducting material inclosing said body, the said sheath being removed for a sufficient distance to expose said envelop, and the said envelop being electrically connected at its ends to said sheath, a wrapping of fibrous insulating material on said envelop, a sleeve of greater diameter than said envelop, inclosing the same and hermetically united at its ends to said sheath, and an insulating fluid adapted to permeate said pervious body contained in the space between said envelop and said sleeve.

In testimony whereof I have affixed my signature in presence of two witnesses.

PHILIP TORCHIO.

Witnesses:
GERTRUDE T. PORTER,
MAY G. MCGARRY.

DISCLAIMER.

1,172,322.—*Philip Torchio*, New York, N. Y. PROTECTIVE DEVICE FOR ELECTRIC-CABLE JOINTS. Patent dated February 22, 1916. Disclaimer filed February 11, 1927, by the assignee, *Thomas E. Murray*.

Hereby makes disclaimer of the improvement described except for electric cables which comprise a line conductor, insulating wrapping permeated with insulating compound and a sheath of flexible inelastic metal constituting a unitary product of manufacture and commerce which is portable and capable of being drawn through conduits; and except as to an insulating liquid which is fluid at ordinary working temperatures of such cables and in quantity sufficient to supply at all times the demands made by the cable in use, and by the joint.

[*Official Gazette March 1, 1927.*]

PLAINTIFF'S EXHIBIT No. 2

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the records of this office of the File Wrapper and Contents in the matter of the

Letters Patent of

Philip Torchio,

Number 1,172,322, Granted February 22, 1916

for

Improvement in Protective Devices for Electric-Cable Joints

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this twenty-first day of January in the year of our Lord, one thousand nine hundred and twenty-seven and of the Independence of the United States of America the one hundred and fifty-first.

ATTEST:

Chief of Division.

Thomas E. Robertson
Commissioner of Patents.

357

NUMBER (Series of 1915.

1915

(EX'R'S BOOK)

259

DIV. 42

PATENT No. 172322

Name Philip Torchio,

of New York,

County of

State of New York.

Invention Protective Devices for Electric cable Joints.

Filed 191

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Attorney Park Benjamin, 165 Broadway, New York, N.Y.

Associate Attorney

No. of Claims Allowed 7, Title as Allowed Protective Devices for Electric Cable Joints (Cl. 174-143)

DIVISION OF INVENTIONS

PARK BENJAMIN
PATENT LAW
160 BROADWAY NEW YORK

RECEIVED
MAR 15 1915
THE CLERK U.S. PATENT OFFICE

RECEIVED
MAR 1 1916

$31.20 applied.

March 11, 1915.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

I forward herewith application of Philip Torchio for Protective Device for Electric Cable Joints, and check for $15 (in ck. for $46.20) in payment of first Government fee.

Respectfully,

Park Benjamin
Attorney for Torchio.

PARK BENJAMIN,
ATTORNEY,
REGISTERED NO. 295,
165 BROADWAY, NEW YORK

Law Reporter Block Print Co.
511 F St., N. W., WASHINGTON, D. C.

MAIL ROOM
MAR 18 1915
U.S. PATENT OFFICE

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RECEIVED
MAR 17 1915

PETITION.

To the Commissioner of Patents:

Division 42, Paper No. 5

Your petitioner Philip Torchio,

a citizen of the United States residing at New York in the County of New York and State of New York and whose Post Office Address is 124 East 15th Street, New York City prays that Letters Patent may be granted to him for the improvement in

Protective Devices for Electric Cable Joints

set forth in the annexed Specification.

And he hereby appoints Park Benjamin, of the City of New York, State of New York, Register No. 295, Attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to sign his name to the drawings, to receive the Letters Patent, and to transact all business in the United States Patent Office connected therewith.

Signed at New York, in the County of New York and State of New York this 9th day of March 1915

(Sign here First name in Full.) Philip Torchio

SPECIFICATION.

To all Whom it May Concern:

Be it known that I, Philip Torchio, a citizen of the United States, residing at New York, in the County of New York and State of New York, have invented a certain new and useful improvement in

Protective Devices for Electric Cable Joints,

of which the following is a specification.

The invention is a device for preventing current leakage at a joint in an electric line conductor, and more particularly at the joints in the line conductors of cables. The invention consists in the construction whereby the joint is immersed in a fluid insulating medium adapted to permeate the pervious wrapping of the joint, whereby said fluid after permeation of said wrapping is retained therein by a denser body of insulating material surrounding said wrapping, and whereby the joint is enclosed in two metallic sleeves united at their ends to one another, separated between said ends and electrically connected at said ends to the cable sheath, whereby the potential on the said sleeves becomes that of the sheath and breaking down of insulation between said sleeve or ionization of air between them is prevented.

In the accompanying drawings -

Fig. 1 is a longitudinal section of my joint. Fig. 2 is a transverse section on the line x, x of Fig. 1. Fig. 3 is an enlarged longitudinal section of a portion of the joint insulation, wire gauze cover and twine wrapping. Fig. 4 is an enlarged transverse section of the same. Fig. 5 is a modified form of my device in which the wire gauze cover, twine wrapping and oil supply reservoir are omitted. Fig. 6 is a modified form of my device in which the wire gauze cover and twine wrapping are omitted and the oil reservoir changed in form.

Similar numbers of reference indicate like parts.

2663

My device is here shown applied to a cable containing a plurality of conductors 1, 2, 3, Fig. 2, each having the usual cover 4 of insulating tape and all enclosed in an outer insulating wrapping 5, the interstices being filled with jute, paper or other pervious insulating material 6. In the ordinary operation of making the joint, the lead sheath 7 of the cable is cut away for a sufficient distance to expose the conductors and permit application of the wrappings, and afterwards a lead sleeve 8 is placed over the joint and connected by wiped solder 9 to the ends of the lead sheathing, thus hermetically enclosing the joint. Through two holes left in the sleeve 8 a fluid insulating compound adapted to permeate the interstices in the insulating wrappings and filling of the joint is poured.

I have found that said fluid compounds do not operate efficiently. In some of them as, for example, paraffine, voids or openings are formed, due to the contraction of the material on cooling and hardening. In others, because of their quick cooling and hardening, due to contact with the cold insulation, the fluid fails to permeate the wrapping and filling. In almost all of them, the insulating liquid ig rendered fluid by heat causes a deterioration of said insulation at the point where said fluid first meets said insulation. In all of them, the insulating compound on hardening will crack under mechanical stresses, especially when the conductors carry heavy overload currents. The consequence is that, by reason of these cracks and voids and the ionization of air in them, a lowering of dielectric strength of the joint insulation takes place, so that electric lines transmitting high

tension currents, especially if underground, have their weakest places at the joints and at the ends of the sheathing 7 where connected to the joint covering sleeve 8. 362

I have succeeded in overcoming the foregoing difficulty by the following means:

In Fig. 1, I show the usual lead covering sleeve 8, provided on its upper side with a reservoir 10 closed by a screw plug 11. I fill the sleeve and reservoir with any suitable insulating oil or other liquid which is fluid at low temperature and preferably of a character which will combine with the material used in the body of the cable for permeating or imbedding the insulating wrappings. This liquid I preferably force into the sleeve 8 under pressure sufficient to drive it into the interstices of the cable ends and into the joint wrappings and fillings. When the introduction of the liquid is complete, I permit it to fill the reservoir 10, which is finally closed. The oil in the reservoir then serves to supply any deficiency in the sleeve caused by absorption and breathing of the cable or the disturbance of the conductors carrying sudden overload currents, so that the joint insulation is not only thoroughly permeated at the outset, but continues submerged in a bath of insulating oil.

Instead of making the reservoir 10 in the form of a separate chamber communicating with the sleeve, as shown in Fig. 1, I may dispose the sleeve eccentrically on the joint, so that the greatest clearance will be uppermost, as shown at 12 in Fig. 6. In this way, I produce an additional holding space for the oil within the sleeve itself.

Where for any reason it is not desirable to keep

the sleeve filled with a light fluid, such as oil, I may first cause the wrappings and filling of the joint to be permeated with said light fluid, as already described, and then afterwards draw off the surplus liquid and substitute therefor an insulating compound of greater density than said liquid to fill the space between the joint and the sleeve. The dense compound then acts both as an insulator and as a means of imprisoning the lighter fluid already in the interstices of the filling and wrappings of the joint.

In order still more effectually to prevent any failure of dielectric strength at the joint, I prefer to enclose the joint wrapping 5 in an envelope 13 of wire gauze, which is electrically connected at its ends a, b to the cut extremities of the lead sheathing on each side of the joint, so that there is a free conducting path between said sheathing extremities through said envelope. This wire gauze enevelope, while permitting free access of liquid into the joint, has the same (ground) potential of the lead sheath. Hence there can be no breaking down of the insulation between the gauze envelope and sleeve 8 even if cracks or voids happen to be formed therein. The gauze envelope can be secured in place by any suitable means - such as a permeable wrapping 14 of tape or twine. I may use this gauze envelope in conjunction with a fluid permeated joint and with fluid between joint and sleeve, as shown in Fig. 1, or with a fluid permeated joint and the annular space surrounding said joint filled with denser insulating compound, as described, or with a fluid permeated joint and simply an air space between joint and sleeve.

It is to be observed that the insulating fluid not only permeates the wrappings and fillings at the joint, but also percolates into the insulation of the cable ends exposed in order to make the joint. This is of practical importance, because it often happens that during the making of the joint, the exposure of said ends permits of the permeating liquid used in the original manufacture of the cable to "bleed" or run out, and a consequent failure of insulation at those points ensues. This I have found to be the cause of breakdowns which were apparently unaccountable. The new fluid put into the joint sleeve supplies this loss and effectually prevents the difficulty.

I claim:

1. An electric cable, comprising a line conductor having a joint, a receptacle enclosing said joint, and an insulating fluid in said receptacle wherein said joint is immersed.

2. An electric cable, comprising a line conductor having a joint, a metallic sheath for said cable, and interposed in said sheath, a receptacle enclosing said joint, and in said receptacle an insulating fluid wherein said joint is immersed.

3. An electric cable, comprising a line conductor having a joint, a metallic sheath for said cable, a receptacle enclosing said joint, an insulating fluid in said receptacle wherein said joint is immersed, and a reservoir for said fluid communicating with said receptacle.

4. An electric cable, comprising a metallic sheath and a line conductor having a joint, the said sheath being removed sufficiently to expose said joint, and two metallic sleeves disposed one within the other and enclosing said joint: the said sleeves being insulated from said joint, united at their ends to one another, separated between said ends, and electrically connected at said ends to said sheath.

5. An electric cable, comprising a metallic sheath and a line conductor having a joint, the said sheath being removed sufficiently to expose said joint, and two metallic sleeves disposed one within the other and enclosing said joint, and an insulating body interposed between said sleeves: the said sleeves being insulated from said joint, united at their ends to one another, separated between said ends, and electrically connected to said sheath.

c3

6. An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material enclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, enclosing the same and hermetically united at its ends to said cable sheath, and an insulating fluid adapted to permeate said pervious body contained in the space between said body and said sleeve.

c4

7. An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material enclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, enclosing the same and hermetically united at its ends to said cable sheath, a receptacle communicating with the interior of said sleeve, and an insulating fluid adapted to permeate said pervious body contained in said receptacle and the space between said body and said sleeve.

8. An electric cable, comprising a sheath, a conductor having a joint, a body of pervious insulating material enclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, enclosing the same and hermetically united at its ends to said cable sheath, the said sleeve being eccentrically disposed upon said body with its maximum clearance uppermost, and an insulating fluid adapted to permeate said pervious body and disposed in the space between said body and said sleeve.

9. An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material enclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, enclosing the same and hermetically united at its ends to said cable sheath, an insulating fluid permeating said pervious body, and a mass of insulating material of greater density than said fluid contained in the space between said body and said sleeve.

10. An electric cable, comprising a metallic sheath, a line conductor having a joint, a body of pervious insulating material enclosing said joint, an envelope of foraminated conducting material enclosing said body, the said sheath being removed for a sufficient distance to expose said envelope, and the said envelope being electrically connected at its ends to said sheath, a sleeve of

greater diameter than said envelope, inclosing the same and hermetically united at its ends to said sheath, and an insulating fluid adapted to permeate said pervious body contained in the space between said envelope and said sleeve.

11. An electric cable, comprising a metallic sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, an envelope of foraminated conducting material enclosing said body, the said sheath being removed for a sufficient distance to expose said envelope, and the said envelope being electrically connected at its ends to said sheath, a wrapping of fibrous insulating material on said envelope, a sleeve of greater diameter than said envelope, inclosing the same and hermetically united at its ends to said sheath, and an insulating fluid adapted to permeate said pervious body contained in the space between said envelope and said sleeve.

Sigs.

In Testimony Whereof I have signed my signature in presence of two witnesses.

Witnesses: [illegible] Rudd
[illegible] May J. McGarry

OATH.

State of New York
County of New York } ss:

Philip Torchio,

the above-named petitioner, being duly sworn, deposes and says that he is a citizen of the United States and resident of the City, County and State of New York and that he verily believes himself to be the original, first, and sole inventor of the improvement in Protective Devices for Electric Cable Joints,

described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application, that said invention has not been patented to him or to others with his knowledge or consent in this or any foreign country for more than two years prior to this application, or on an application for a patent filed in any country foreign to the United States by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said improvement has been filed by him or his representatives or assigns in any country foreign to the United States, ~~except as follows~~:

(Sign here First name in full.) Philip Torchio

Sworn to and subscribed before me this 9th day of March 1912.

42 Room 244
The Commissioner of Patents,
Washington, D. C.,
and not any official by name.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON July 2, 1915.

Park Benjamin,

165 Broadway,

New York, N.Y.

Philip Torchio, for Protective Devices for Electric Cable Joints

Ser. No. 14078, filed March 13, 1915.

Claim 1 is rejected on

Purcell,	488,027,	Dec. 13, 1892, (173-268);
Biele,	888,674,	May 26, 1909, " "
Egerton,	1,073,596,	Sept. 23, 1913, " "

Claim 2 is not clear in the expression "interposed in said sheath", and is also rejected on the same references as claim 1.

Claim 3 is rejected on

Patterson,	327,335,	May, 9, 1885, 173-268, or
Wesslau,	416,143,	Nov. 26, 1889, " " .

Claims 4 and 5 are rejected on

Wiley et al,	433,922,	Aug. 5, 1890, 173-268, or
Rosati,	706,599.	Aug. 12, 1902, 173-268.

There is no invention in having a body of pervious insulating material enclosing the joint, and claims 6, 7, 9, 10 and 11 are rejected on the same references as claim 4.

Claim 8 is for a different species from the other claims in the case and should be divided out since only one species can be claimed in the same case.

E. C. Jarvell
3/5 Examiner Div. 4

MAILROOM OCT 7 1915 PATENT OFFICE

RECEIVED OCT 8 1915

A M E N D M E N T Division 42, Paper No. 3

Amendment

Div. 42, Oct. 1915
In the Matter of the
Application of
Philip Torchio,
PROTECTIVE DEVICES FOR
ELECTRIC CABLE JOINTS,
Serial No. 14,079,
Filed March 13, 1915.

No. [illegible] Broadway,
New York City, Oct. 6, 1915.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

In answer to official action of July 8, 1915.

Erase claims 1, 2, 3. Renumber remaining claims in order.

Rosati does not show two metallic sleeves disposed one within the other and enclosing the joint, which are united at their ends to one another and electrically connected at their ends to the sheath. Only the outer sleeve c is connected to the enclosing tube b, which is not a cable sheath, as the term is now understood and as shown in applicant's drawings, but merely a conduit pipe. The sleeve h is connected only to the conductors a. This has nothing to do with applicant's device and cannot possibly produce the results which he sets forth.

In Wiley et al, the sleeve E is of insulating material (spec., page 1, line 18) which, of course, cannot be "electrically" connected to anything.

Claims 6, 7, 9, 10 and 11 do not relate solely to "a body of pervious insulating material enclosing the joint" but to certain combinations, the object and purpose of which is fully set out in the specification. The

140[illegible]

the references above noted wholly fail to apply, for the reasons already given. If the Examiner's holding is flatly that these combinations involve no invention, no reason appears for that conclusion, and the specification traverses it. Applicant can, therefore, merely interpose a denial and insist on the claims as they stand.

We fail to see how claim 8 sets forth any different species. The eccentric disposition of one of the sleeves is merely a specific way of forming the oil receptacle more broadly recited in claim 7.

Reconsideration is respectfully requested.

Respectfully,

Attorney for Torchio.

373

42... No. 244

DEPARTMENT OF THE INTERIOR.

MFB UNITED STATES PATENT OFFICE

WASHINGTON Nov. 29, 1915.

185

Park Benjamin,

165 Broadway,

New York, N. Y.

Please find below a communication from the EXAMINER in charge of the application of

P. Torchio, for Protective Devices for Electric Cable Joints, Ser. No. 14078, filed March 17, 1915.

Thomas Ewing

Commissioner of Patents.

This action is responsive to amendment filed Oct. 7, 1915.

It is not believed that claim 4 (original 7) can be fairly read on Fig. 6. The claim embodies among its elements, "a sleeve of greater" etc. and also as an element "a receptacle communicating with the interior of the sleeve". This clearly defines Fig. 1 but not Fig. 6.

Claim 5 (original 8) is limited to fig. 6.

Claims 1, 2, 4, 7 and 8 are limited to fig. 1 and claim 5 to fig. 6 as the case is now presented, and division between these specific constructions is hereby made final.

Claims 3 and 6 appear to be generic to either form.

2/18 T. D. Ewing

2/14

DEC 11 1915 U.S. PATENT OFFICE

RECEIVED DEC 2 1915

AMENDMENT

Division 42, Paper No 5

Amendment B

Div. 42, Room 244
In the Matter of the
Application of
Philip Torchio,
PROTECTIVE DEVICES FOR
ELECTRIC CABLE JOINTS,
Serial No. 14,078,
Filed March 13, 1915.

No. 165 Broadway,

New York City, Nov. 30, 1915.

Hon. Commissioner of Patents,

Washington, D. C.

S i r :

In answer to official action of November 29, 1915, and in view of the requirement for division, erase claim 5. Renumber remaining claims in order.

Respectfully,

Attorney for Torchio.

ADDRESS ONLY
THE COMMISSIONER OF PATENTS,
WASHINGTON, D. C.

D. 2-181 Serial No. 14,075.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON Jan. 15, 1916.

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

UNCERTIFIED CHECKS WILL NOT BE ACCEPTED.

Philip Torchie,

Sir: Your APPLICATION for a patent for an IMPROVEMENT in Protective Devices for Electric Cable Joints, filed March 13, 1915, has been examined and ALLOWED.

The final fee, TWENTY DOLLARS, must be paid not later than SIX MONTHS from the date of this present notice of allowance. If the final fee be not paid within that period, the patent on this application will be withheld, unless renewed with an additional fee of $15, under the provisions of Section 4897, Revised Statutes.

The office delivers patents upon the day of their date, and on which their term begins to run. The printing, photolithographing, and engrossing of the several patent parts, preparatory to final signing and sealing, will require about four weeks; and such work will not be undertaken until after payment of the necessary fee.

When you send the final fee you will also send, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR, TITLE OF INVENTION, AND SERIAL NUMBER AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If you desire to have the patent issue to ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this office on or before the date of payment of final fee.

After issue of the patent uncertified copies of the drawings and specifications may be purchased at the price of FIVE CENTS EACH. The money should accompany the order. Postage stamps will not be received.

Final fees will NOT be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Respectfully,

Thomas Ewing
Commissioner of Patents.

Peck Benjamin,

165 Broadway, New York, N. Y.

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RECD JAN 21 1916 U.S. PAT. OFFICE

PARK BENJAMIN
PATENT LAW
115 BROADWAY, NEW YORK

January 20, 1916.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:-

I forward herewith re application of Philip Torchio for Protective Devices for Electric Cable Joints, filed March 13, 1915, Serial No. 14,078, allowed Jan. 15, 1916, check for $20 (in ck. for $80) in payment of final Government fee.

Respectfully,
Park Benjamin
Attorney for Torchio.

1172

United States District Court

#6229

Northern District of OHIO-- EASTERN DIVISION--

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

SIR:

In compliance with the Act of February 18, 1922 (42 Stat. L.), you are advised that there was filed on the 27th day of February, 1926, in this court an action, suit, or proceeding No. 1772 entitled:

Name: Metropolitan Device Corporation, Plaintiff,
Address: Brooklyn, New York

versus

Name: Cleveland Electric Illuminating Company, Defendant,
Address: Cleveland, Ohio.

brought upon the following patents:

PATENT NO.	DATE OF PATENT	PATENTEE
1,172,322	March 13, 1915	Philip Torchio

In the above-entitled case, on the day of 192 the following patents have been included by (insert amendment, answer, crossbill, or other pleading):

PATENT NO.	DATE OF PATENT	PATENTEE

In the above-entitled case the following decision has been rendered or decree issued.

In witness whereof I have affixed my hand this 27th day of February, 1926, at Cleveland, Ohio.

B. C. MILLER,
Clerk of said Court.
BY W. E. Reve, Deputy
W. E. REVE

2/22 * 1408-20

1915

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[fo 379] PLAINTIFF'S EXHIBIT No. 3

390

Department of Commerce, United States Patent Office

To all persons to whom these presents shall come, Greeting:

This is to Certify that the annexed is a true copy from the records of this office of Disclaimer, filed February 11, 1927, in the matter of the Letters Patent of Philip Torchio, Number 1,172,322, Granted February 22, 1916, for Improvement in Protective Devices for Electric-Cable Joints.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this twelfth day of February in the year of our Lord, one thousand nine hundred and twenty-seven and of the Independence of the United States of America the one hundred and fifty-first.

Thomas E. Robertson, Commissioner of Patents.

Attest: D. Eribelson, Chief of Division. (Seal.)

[fol. 380] D. Anthony Usina, 71 Broadway, New York

2249. Disclaimer

Hon. Commissioner of Patents, Washington, D. C.

SIR: Your Petitioner, Thomas E. Murray, a citizen of the United States, residing in Brooklyn, County of Kings and State of New York, represents that in the matter of a certain improvement in Protective Devices for Electric-Cable Joints for which Letters Patent of the United States, No. 1,172,322 were granted to Philip Torchio on the 22nd day of February, 1916; he is assignee of the entire right, title and interest, as shown by an assignment from said Torchio dated June 10, 1922, and recorded in Liber W-116, Page 275 of Transfers of Patents, and that he has reason to believe that through inadvertence, accident or mistake and without any fraudulent or deceptive intention, the specification and claims of said Letters Patent may be construed too broadly so as to include that of which said patentee was not the first inventor.

Your Petitioner, therefore, hereby makes disclaimer of the improvements described except for electric cables which comprise a line conductor, insulating wrapping permeated with insulating compound and a sheath of flexible inelastic metal constituting a unitary product of manufacture and commerce which is portable and capable of being drawn through conduits; and except as to an insulating liquid [fol. 381] which is fluid at ordinary working temperatures of such cables and in quantity sufficient to supply at all times the demands made by the cable in use, and by the joint.

Signed at New York City, New York, this 10th day of February, 1927.

Thomas E. Murray.

Witnesses: May E. Fleck, William K. Seewagen.

Disclaimer recorded in Issue Division record Book Feb 12, 1927.

PLAINTIFF'S EXHIBIT No. 4

Technical Session

Report of the Committee on Underground Construction

Presented by W. L. Abbott, Chicago; Geo. W. Cato, Detroit, Mich.; P. Torchio, New York, N. Y.; L. J. Lisberger, San Francisco, Cal.; H. B. Alverson, Buffalo, N. Y.; Burton French, New Orleans, La.; E. B. Meyer, Newark, N. J.

[fol. 382] Read Before the National Electric Light Association at Its Thirty-fourth Convention, Held at New York City, May 29 to June 2, 1911

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diameter of the copper sleeve; then continue wrapping back and forth in the space between the two ends of the original paper insulation until it is built up level full.

Commencing at a point on the covered conductor 3″ from the outer or over-all insulation at one end of the joint, lay on a wrapping of tape extending to a point 3″ from the outer insulation at the other end of the joint. Now go back and forth across the space covered by the first wrapping, stopping each successive layer ½″ short of the end of the preceding layer. Continue this process until the insulation is piled up to a thickness over the copper sleeve equal to 40 per cent greater than the original paper insulation.

In applying the tape, each turn should be drawn tight to exclude air, and should overlap the preceding turn by two-thirds of its width. Each layer when finished should be saturated with hot filler, either by pouring or with a brush. After all three conductors are joined and insulated as described, a roll of tape ½″ in diameter is inserted between them at the center of the joint to serve as a spreader. [fol. 383] A band of tape is now wrapped around all three conductors to such a diameter that the whole will slide nicely into the lead sleeve, which is next pulled over the joint, centered, and its ends beaten down to the cable sheaths and sealed at each end with a wiped joint, after which a hole about ¾″ square is to be cut in the sleeve near each end by cutting around three sides of the square and folding back the piece of lead on the fourth side as a hinge. After placing the joint in a level position the sleeve is to be filled with paraffine or compound heated to 150° C.

After cooling for an hour or an hour and one-half, depending upon the atmospheric temperature, hot-filler should be again poured into each of the openings to fill any cavities which may have formed during the cooling. Care should be taken to see that the joint is in a level position so that the filler will run from both of the openings at the same time.

The lead flaps cut from the small openings in the sleeve through which the compound was poured are then to be folded back into place and carefully sealed. Special attention should be paid to the sealing of these openings, in order to be sure that the seal is absolutely watertight and that no solder gets inside the sleeve.

After the joint has been completed the jointer will stamp his initials on the wipe at each end of the sleeve, in such a location that they can readily be seen.

Sleeve Filling Material

As a filling for the sleeve of a cable joint, several companies use some form of a prepared insulating compound, [fol. 384] while other companies use nothing but paraffine for the purpose; the preference among the companies reporting being in favor of paraffine, although each company appears to be perfectly satisfied with the filling material which it is using.

Some of the properties which are considered desirable for a good jointing compound are:

1. High melting point.
2. Adhesiveness.
3. Not brittle at ordinary temperatures.
4. Resistance to puncture tests.
5. Low coefficient of contraction.

Some of the objections to the use of paraffine are: It does not have the property of sticking tight to smooth surfaces. It becomes extremely fluid at about 125 or 130 degrees Fahrenheit. It has an excessive contraction coefficient, causing voids which have a dielectric strength lower than ordinary air.

Paper Tube Joints

The method of making this joint is well described in the advertising matter of a company advocating its use, as follows:

The individual conductors are prepared for jointing in the regular way. Before they are joined together, a special paper tube 4½" to 5" long, of suitable thickness and of an internal diameter sufficient to easily pass over the insulation of the conductor, is slipped on each conductor; a large tube is slipped over these and pushed back, so that the wires [fol. 385] can readily be spliced. After the wires are spliced and all sharp points of solder or sharp edges on the connectors carefully removed, the spaces between the conductors and the insulation are carefully filled with cotton or paper tape, and this tape is wrapped evenly and tightly over the connectors, so as to continue the insulation over

them to the same diameter as the original insulation on the individual conductor.

The use of cotton tape is preferred, because it absorbs the insulation better than paper when the insulation compound is poured on, as is done in actual construction. Such tape can also be more tightly packed by hand than can paper tape, and thus all air spaces are more surely eliminated.

The cotton tape having been thoroughly boiled out with hot compound, the paper tubes are then slipped over the splices, the larger tube over the three smaller ones, and all fastened in position by one wrap of cotton tape. The lead sleeve is then wiped to the cable sheath, filled with compound in the usual manner, allowed to settle, refilled, and the holes in the sleeve permanently closed.

Advantages of Paper Tube Joint

The following points of superiority are claimed for the above type of joint:

(a) Absolute certainty of proper insulation and separation between conductors and between conductors and lead, the judgment of the workmen as to these points being entirely eliminated.

[fol. 386] (b) Freedom from moisture, the tubes being thoroughly impregnated with insulation at the factory by immersion in hot compound.

(c) Freedom from air spaces. The fact that there are no convolutions of tape to be penetrated by the compound used in filling the sleeve makes it certain that the entire joint will be thoroughly filled.

(d) Ease of application, with consequent saving in labor and expense.

PLAINTIFF'S EXHIBIT No. 5

Transactions of the American Institute of Electrical Engineers, January to December, 1917

Volume XXXVI

Published by the American Institute of Electrical Engineers, 33 West Thirty-ninth Street, New York, N. Y., U. S. A., 1917

If some formed or molded insulation is used it should be held in position temporarily by the form of the insulation, [fol. 387] or by tying with string or tape. The solid insulation should be so made and held in position in the joint that when slightly tilted at the time of filling, all of the air within the enclosing sleeve will be driven out by the filling compound.

7. All moisture should be carefully excluded from the joint.

For the purpose of excluding moisture it may be necessary to install some temporary shelter so as to prevent drippings from the roof, or contact with the adjacent wall of the manhole. Moisture in the insulating tape should be driven out by dropping it in a vessel containing filling compound heated considerably above the boiling point of water. Rubber gloves should be worn by the cable splicer in warm weather, and at other times if the hands are naturally moist. The splicer should also take suitable precautions to insure that no perspiration drops from the face into the joint.

8. If filling compound with a low melting point is used, precautions should be taken to prevent the compound from running back into the cable at the maximum operating temperature.

If the impregnating compound in the cable does not entirely fill the interstices between the strands of the conductors, as well as the insulation, then the filling compound as it becomes fluid may run back into the cable. This would leave voids in the upper part of the cable sleeve and would

give a distribution of dielectric stresses that would probably later cause trouble. If such compounds are used the [fol. 388] soldering of the splicing sleeve should extend beyond the ends of the sleeve, and in addition, several wrappings of impervious tape should be applied to the conductors where exposed between the splicing sleeve and the original insulation around the conductor.

A thin filling compound may also flow back into the jute filling between conductors if it is not thoroughly impregnated. The use of a filling compound with a low melting point should, therefore, be avoided unless the insulation, the jute, and the conductor are all very thoroughly filled with the impregnating compound.

9. The initials, or some other symbols, should be stamped on the joint to indicate the name of the splicer.

This stamp can be made in the wipe without danger of damaging the joint. Good cable splicers, like other first class workmen, take considerable pride in their work, and it makes them

PLAINTIFF'S EXHIBIT No. 6

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(No Model.)

W. R. PATTERSON.

SPLICE FOR TELEGRAPH CABLES.

No. 277,335. Patented May 8, 1883.

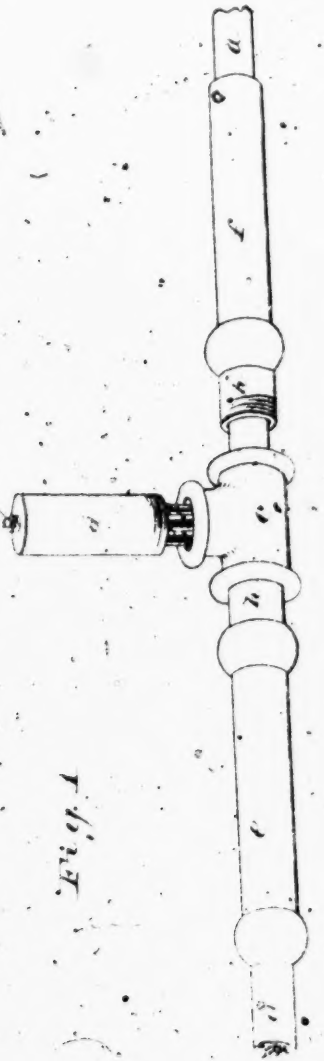

Fig. 1.

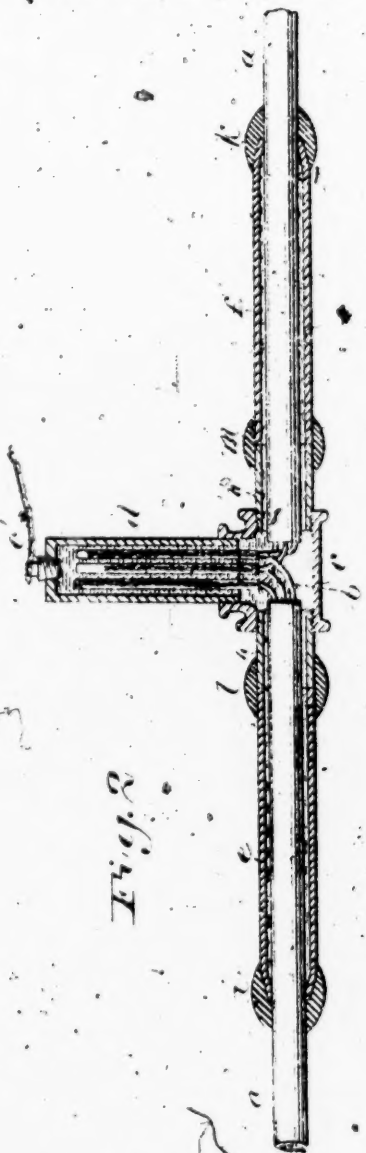

Fig. 2.

Witnesses
Paul A. Staley.
J. A. McKenney

Inventor
William R. Patterson
By George P. Barton
Attorney

UNITED STATES PATENT OFFICE.

WILLIAM R. PATTERSON, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE WESTERN ELECTRIC COMPANY, OF SAME PLACE.

SPLICE FOR TELEGRAPH-CABLES.

SPECIFICATION forming part of Letters Patent No. 277,335, dated May 8, 1883.

Application filed November 13, 1882. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM R. PATTERSON, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Splices for Telegraph-Cables, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to splicing the lead pipe and conducting-wires of underground-telegraph cables; and it consists in a metallic covering of considerable length placed about the pipe of the cable and extending in either direction from the joint, in combination with an insulating substance, as hereinafter described and claimed. The extreme end of the covering should be of lead. The central portion of the covering is a T-shaped piece, and is adapted to receive the sleeves and cap of the covering. The inner sections of the sleeves should be of harder metal than lead. I prefer brass. The brass and lead sections of the different sleeves are conveniently joined by ordinary wipe-joints. After the sleeves are screwed into the T-piece, which is preferably an iron casting, the extreme ends of the sleeves are united with the lead pipe of the cable by ordinary wipe-joints. The metallic covering thus formed is then filled with melted paraffine or other insulating substance, which becomes solid, like paraffine, when allowed to cool. The joints of the wires are thus protected from moisture and external injury by the metallic covering filled with paraffine or other wax.

Figures 1 and 2 are illustrative of my invention.

a is the cable, consisting of a flexible metallic pipe containing a core of insulated conductors *b b*. The wires of the conductors are covered with a fibrous material, and the interstices among the conductors, and between them and the lead pipe, are filled with paraffine or other insulating material in any of the well-known ways. In order to form a perfect splice, the corresponding wires of the two pieces of cable must be united, and the different joints of the wires must be insulated and fully protected.

The metallic covering consists of the T-shaped piece, the cap *d*, and the sleeves *e* and *f*. The outer ends of the sleeves should be of lead, while the parts *h h* should be of harder metal, preferably brass. The T shaped piece *c* must be of hard metal, like brass or iron, and the cap *d* may be of iron.

In order to unite two pieces of cable, I first cut away the lead pipe, so that the wires may project a short distance. I then slip the sleeves *e f* over the two ends of the cable and screw the said sleeves into the T-piece, as shown, bringing the projecting ends of the wires through the outlet of the T-piece. The bare ends of the wires are then twisted together, and the joints thus formed covered with glass tubes, as shown in Patent No. 233,162, granted me October 12, 1880. I then wipe joints *i k*. These joints must be far enough from the ends of the cable so that the paraffine which is melted by the heat may not run out, so as to come into contact with the solder. I make the sleeves, therefore, of considerable length, as shown. The outer ends of the sleeves are first compressed about the lead pipe of the cable, and the joints are then wiped in the usual manner. After the cap *d* is inserted I remove the screw-plug *c'*, and then turn or force in melted paraffine or other melted insulating substance.

If the paraffine is quite hot, it is not necessary to use pressure. I prefer, however, to attach a force-pump to the opening in the cap and put on enough pressure to test the joints *i k* of the splice.

The joints *l m* of the sleeves are made in the shop, and hence may be relied on. The screw-joints may be made perfect, if the threads are cut with care. The joints *i k*, however, must be made in the trench, and are therefore less reliable. The paraffine, however, between the pipe of the cable and sleeves keeps out all moisture though joints *i k* should be somewhat imperfect. The sleeves of the splice of an inch and a quarter cable should be about eighteen inches each in length. For smaller cables, where less heat is required in making the joints, the sleeves may be shorter. Sufficient length to allow the joints to be wiped without danger of mixing the melted paraffine with the solder is all that is required.

Having thus described my invention, what

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277,335

I claim as new and original, and desire to secure by Letters Patent, is—

1. The combination, with the joints of the wires and the lead pipe of a telegraph cable, of a metallic covering, the outer ends of which are adapted to be compressed about and joined to the pipe, the portions *h* being of harder metal, like brass, and adapted to screw into the central piece, and a filling of paraffine or other insulating substance which solidifies when cool, whereby the space between the pipe and the covering is filled and the joints protected, as and for the purpose specified.

2. The combination of two metallic sleeves united to the lead pipe of a telegraph cable, a T-piece joining said sleeves, a cap connected to the outlet of said T, the joints of the conductors, and a filling of insulating substance, substantially as and for the purpose set forth.

3. The combination, with the joints of the conductors of a telegraph cable, of a T, through which the said conductor-joints pass, a cover adapted to screw into said outlet, over said conductor-joints, and two sleeves, each of which is at one end adapted to screw into said T, and at the other end adapted to be soldered to the metallic pipe of the cable, said sleeves being extended for a considerable distance over said pipe, whereby the insulator melted in said pipe by the soldering process is prevented from running out at the ends of said pipe, substantially as specified.

4. A splice for lead pipe telegraph-cables, consisting of two metallic sleeves joined by a T, said sleeves being extended over and joined to the lead pipe of the sections of the cable to be joined, in combination with the joints of the electrical conductors, said conductors being extended through the outlet of the said T, and covered by a cap connected to the outlet of said T, substantially as set forth.

In witness whereof I hereunto subscribe my name this 9th day of October, A. D. 1882.

WILLIAM R. PATTERSON.

Witnesses:
P. A. STALEY,
GEORGE P. BARTON.

PLAINTIFF'S EXHIBIT No. 6 A

394
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(No Model.)

B. H. WESSLAU.

COUPLING FOR UNDERGROUND CABLES.

No. 416,143. Patented Nov. 26, 1889.

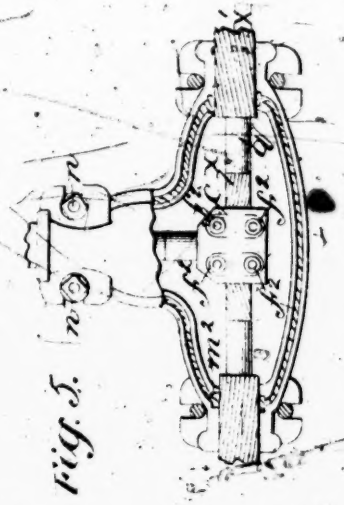

Fig. 5.

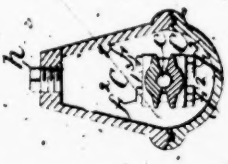

Fig. 4.

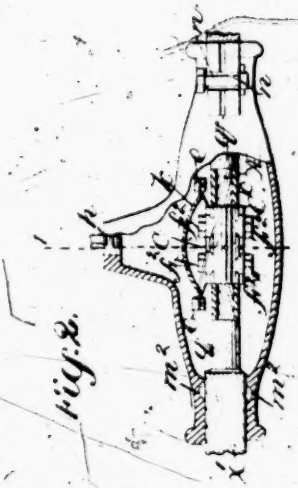

Fig. 2.

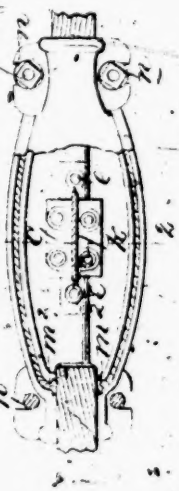

Fig. 3.

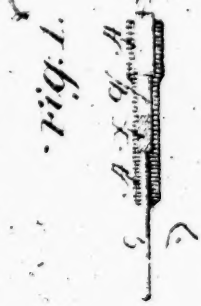

Fig. 1.

Witnesses:
Chas. Hoffer
Wm. H. Kemp

Inventor:
Bro. Hermann H. Wesslau
By C. S. Whitman.
Attorney

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UNITED STATES PATENT OFFICE.

BROR HEMMING WESSLAU, OF CHARLOTTENBURG, PRUSSIA, GERMANY.

COUPLING FOR UNDERGROUND CABLES.

SPECIFICATION forming part of Letters Patent No. 416,143, dated November 26, 1889.

Original application filed February 4, 1887, Serial No. 226,575. Divided and this application filed December 29, 1888. Serial No. 294,937. (No model.) Patented in Germany April 27, 1887, Nos. 42,256 and 43,673; in England September 2, 1887, No. 11,932; in France December 20, 1887, No. 187,711, and in Austria-Hungary February 18, 1888, No. 44,641 and No. 5,213.

To all whom it may concern:

Be it known that I, BROR HEMMING WESSLAU, a subject of the King of Prussia, German Emperor, residing at Charlottenburg, in the Kingdom of Prussia, German Empire, have invented certain new and useful Improvements in Devices for Coupling Underground Cables, (which have been patented in the German Empire by Letters Patent No. 42,256 and No. 43,673, of April 27, 1887, and in England by Letters Patent No 11,932, of September 2, 1887; in France by Letters Patent No. 187,711, of December 20, 1887; in Austria-Hungary by Letters Patent No. 44,641/87, tome 38, folio 351, and No. 5,213, tome XXII, folio 325, of February 18, 1888;) and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same.

My invention has for its object to provide a new and simplified construction of joints for coupling underground cables having only one conductor, and of cases or boxes for protecting the same from external injuries, this application being a division of one filed by me on the 4th day of February, 1887, Serial No. 226,575.

Cables which are used to convey electric energy generated at some point to places of consumption at greater or less distances must, partly with one another, partly with other conductors, be electrically connected. For this purpose connections are necessary which have to fulfill two requirements: In the first place, such connections must be safe mechanically and electrically, and, secondly, be well insulated and protected against injury. Different kinds of such connections are necessary, as will be hereinafter stated and described.

Referring to the accompanying drawings, in which corresponding parts are designated by similar letters, Figure 1 is a plan view, partly in section, of an end-closure according to my invention, which is adapted to be used with a cable the conductor of which consists of a single solid wire. Fig. 2 is side view, partly in section, of a connector adapted to connect two cables. Fig. 3 is a top plan view, with the box partly broken away, showing the interior thereof. Fig. 4 is a vertical section on line 1 2 of Figs. 2 and 3; and Fig. 5 is a top plan view, with the box partly broken away, showing the interior thereof of a connector adapted to connect three cables.

I use for the electrical connection of the conductor of a cable with other conductors at the engine-house, &c., an "end-closure," thus termed because the insulating-layer of lead cable covering the conductor is to be closed air-tight against the permeation of moisture, which destroys the insulation of the cable. With cables the conductor of which consists of a single solid wire the end-closure is an insulating-sheathing A—for instance, a rubber hose shoved on, a rubber band wound around, or a woven or braided tape saturated with an insulating compound coiled around the cable. The several layers put on the conductor, and of which the cable is composed, are cut off into steps before the application of the insulating-sheathing A, so that it covers part of the surface of the conductor *c*, part of the insulating-layer *r* covering the conductor and part of the lead covering *q*, and part of the insulating and protecting layer *r'* surrounding the lead covering. In this manner between the conducting-wires and lead covering a sufficiently large space is provided so that no loss of current by short-circuiting can take place, and, besides, the insulating-layer covering the conductor is hermetically closed against the permeation of moisture. The conductive connection of the said end of a solid-wire conductor with other conductors is accomplished in the manner known by means of binding-screws.

The connector illustrated in Figs. 2, 3, 4, and 5 serves to connect two cables of the same or different cross-section of the conductor. It consists of two rectangular metal blocks C, provided with grooves and perforated near their corners, which blocks, with their grooved surfaces embracing the conductors, are firmly pressed together by means of screws *f'*, passing through the said perforations. Any test-wires which have been twisted up with the copper conductors are bent somewhat upwardly and electrically connected with each

other by means of two clamps *e* and an insulated connecting-wire *k*. In order to well insulate this joint and to protect it from mechanical injury, as well as to prevent the permeation of moisture into the insulating-layer surrounding the conductor, an iron box is used, which consists of two flanged halves, into which the cable ends, already protected from moisture in the manner hereinbefore described, are introduced. The flange of the bottom half is provided with a groove, to be filled with hemp or any other packing material, the flange of the upper half receiving a projection which, on screwing the halves together, enters into the said groove, and thus firmly presses the packing material into it. At the place where the cables are introduced into the box both the halves of the box receive semi-cylindrical apertures with a groove m^2 for the reception of the packing material.

In order to screw both the halves of the box together, the flanges at the places where the cables are introduced are provided with cuts for the reception of the screws *n*. The top of the box is rounded out in the shape of an obtuse cone, the upper part of which cone is provided with a thread for the reception of the screw-plug *h*. When both halves of the box are firmly screwed together, the entire hollow space is filled with an insulating compound and closed by the screw-plug.

A T-shaped box is provided for the electrical connection of a branch line with a main through-going cable, and also for an electrical connection of three cables meeting at a certain point. The construction of this agrees in the main with the straight box above described. The difference consists in the two rectangular metal blocks of the connector receiving an additional groove, running laterally, suited to the circumference of the third conductor, and in the two halves of the box receiving a lateral widening with an aperture for the passage of the third cable. The introduction of the cable, the packing, and the filling with the insulating compound is accomplished in the same manner as with the connection-box described heretofore.

Having now described my invention, what I claim, and desire to secure by Letters Patent, is—

In a connector for underground cables, the combination, with a box constructed of two halves having a corresponding groove and flange, the upper half thereof forming a dome and having a screw-hole in the upper part thereof, of metallic blocks having grooves therein for receiving the cables and contained within the said box, blocks for connecting test-wires, also contained within the said box, the remaining space therein being filled with liquid insulating material, and a screw-plug fitting into the screw-hole in the dome of the box, as and for the purposes described.

In testimony whereof I have hereunto set my signature in presence of two witnesses.

BROR HEMMING WESSLAU.

Witnesses:

MAX WAGNER,

B. ROL

PLAINTIFF'S EXHIBIT No. 6 B

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(No Model.)

G. L. WILEY & E. G. ACHESON.

JOINT FOR ELECTRIC CONDUCTORS.

No. 433,922. Patented Aug. 5, 1890.

Fig. 1.

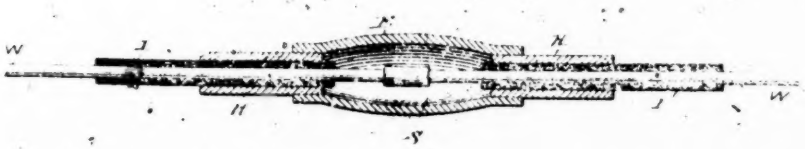


Fig. 2.

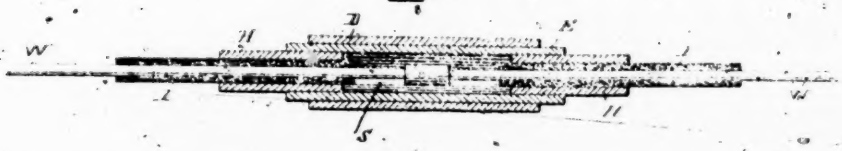


Fig. 3.

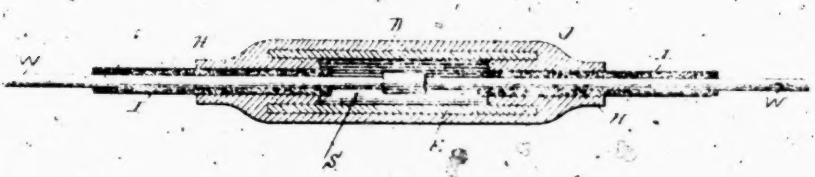
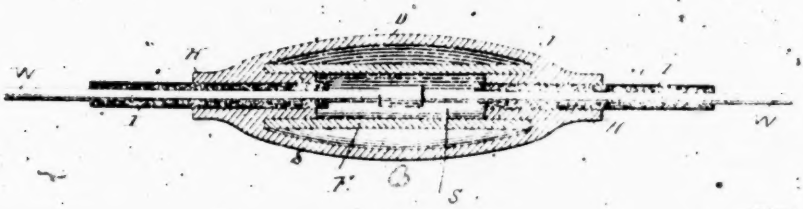


Fig. 4.



WITNESSES
Jno. G. Hinkel
Georgia B. Kramer

INVENTOR
G. L. Wiley
E. G. Acheson
by Foster & Freeman
Attorneys

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UNITED STATES PATENT OFFICE.

GEORGE L. WILEY, OF ARLINGTON, NEW JERSEY, AND EDWARD G. ACHESON, OF PITTSBURG, PENNSYLVANIA, ASSIGNORS TO THE STANDARD UNDERGROUND CABLE COMPANY, OF PITTSBURG, PENNSYLVANIA.

JOINT FOR ELECTRIC CONDUCTORS.

SPECIFICATION forming part of Letters Patent No. 433,922, dated August 5, 1890.

Application filed March 27, 1890. Serial No. 345,570. (No model.)

To all whom it may concern:

Be it known that we, GEORGE L. WILEY and EDWARD G. ACHESON, citizens of the United States, residing, respectively, at Arlington, in the county of Hudson and State of New Jersey, and at Pittsburg, Allegheny county, State of Pennsylvania, have invented certain new and useful Improvements in Joints for Electric Conductors, of which the following is a specification.

Our invention is a joint for electric conductors, especially for that class of conductors which are provided with a metallic covering—usually of lead—and are adapted for the passage of currents of high tension. It is well known that the greater part of the difficulties met with in obtaining high values of insulation in such conductors is due to leakages at or about the joints or places where connections are made between different portions of the conductor. In order to obviate these troubles and to insure perfect insulation at these joints, much effort and labor have been expended.

Our present invention provides a joint which we have found to be safe, cheap, and efficient, and capable of producing the desired efficiency of insulation, and we have illustrated the same in the accompanying drawings, in which—

Figure 1 is a sectional view of a cable arranged according to our invention. Fig. 2 is a similar view of a joint provided with a protecting device. Fig. 3 is a similar view showing a manner of connecting the protecting device with the metal of the cable, and Fig. 4 is a modification of the same.

In the drawings, W W represents a metallic electric conductor, which may be of any desired form or construction, the adjacent ends of the sections of the cable being united electrically in a well-known way. The insulating material I surrounding these conductors is removed from the ends of the cables for a certain distance, leaving the conductor bare, and the usual metal or protecting covering H of the conductor is also removed. Before the ends are joined a tube E or other hollow section of porcelain, vulcabeston, hard rubber, papier-maché, or other suitable non-conductor is slipped over one end of one of the cables, and after the junction of the conductors is effected this tube is slipped over the junction so as to bear upon the metal covering H of each end of the adjacent cable. This tube may be made to fit tightly over the metal covering, or, if necessary, some insulating material may be interposed between the tube and the metal covering to complete and effect the union.

The conductors W between the adjacent ends of the cables may be insulated by winding with tape or covered and surrounded by other insulating material, so as to fill the space S, or, if preferred, it may be left vacant. In order to protect this tube from breakage in places where it is exposed, we provide a metal tube or sleeve D, which may be of lead or other similar material and which acts as a mechanical protector to the sleeve of insulating material.

In Fig. 2 we have shown this mechanical protecting-sleeve simply fitting over the insulating-sleeve E.

In Fig. 3 we have shown the sleeve D as consisting preferably of a section of lead pipe or similar material, fitting over the insulating-tube and connected to the protecting-covering H of the cable by means of a wiped joint J at both ends. In this way the insulated tube is fully covered throughout and a neat finish and joint are made.

In Fig. 4 we have shown the mechanical protecting-tube D as being somewhat larger than the insulating-tube E, leaving a space between the two, and the protecting-tube is connected to the metallic protecting-covering of the cable by a wiped joint J, as before. We have found that this construction is a safe joint, in that all moisture is prevented from reaching the conductors, and when the protector is used it is not liable to be broken or destroyed under any of the ordinary conditions to which it is exposed.

What we claim is—

1. A joint for electric conductors in which the insulated and protected conductors are exposed at its adjacent ends and the space

cable are joined by a sleeve of insulating material closely fitting the metallic coating at the adjacent ends of the cable, substantially as described.

2. A joint for electric conductors in which the insulated and protected conductor is exposed at its adjacent ends and the ends of the cable are joined by a sleeve of insulating material closely fitting the metallic coating, and a metallic protective sleeve covering the insulating-sleeve, substantially as described.

3. A joint for electric conductors in which the insulated and protected conductor is exposed at its adjacent ends and the ends of the cable are joined by a sleeve of insulating material closely fitting the metallic coating, the protective sleeve surrounding the metallic covering of the cable and united thereto by a metallic union, substantially as described.

4. A joint for electric conductors in which the insulated and protected conductor is exposed at its adjacent ends and the ends of the cable are joined by a sleeve of insulating material closely fitting the metallic coating, the protective sleeve surrounding the metallic covering at a distance therefrom, leaving a space between the two, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

GEORGE L. WILEY.
EDWARD G. ACHESON.

Witnesses:
W. D. UPTEGRAFF,
THOS. F. O'CONNOR.

PLAINTIFF'S EXHIBIT No. 6C

402
301

(No Model.)

J. J. PURCELL.

ELECTRIC COUPLING.

No. 488,027 Patented Dec. 13, 1892.

Fig. 1.

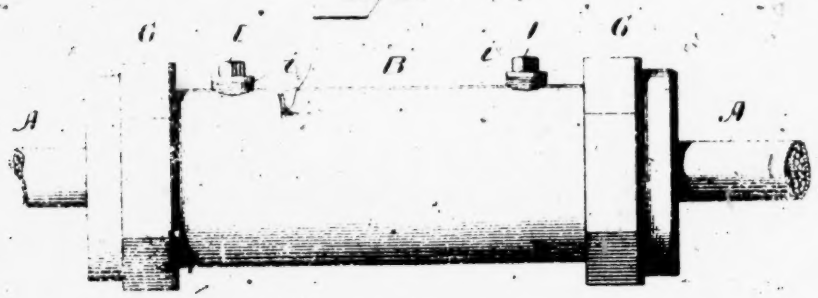


Fig. 2.

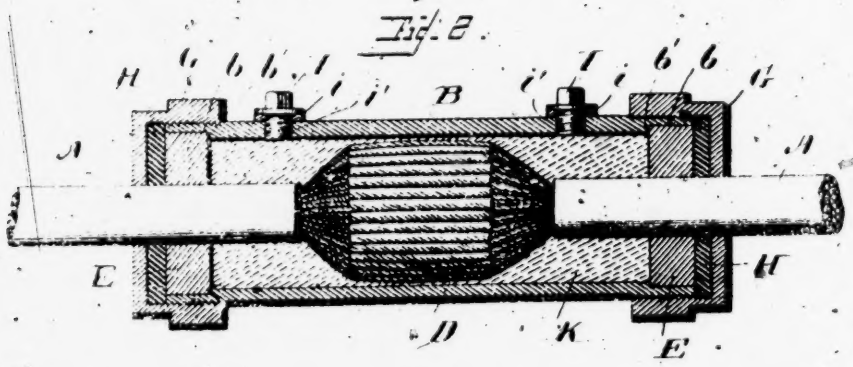
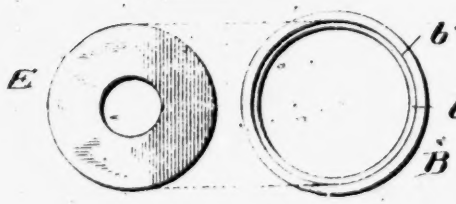


Fig. 3.



Witnesses
Albert Scudder
A. L. Hough

Inventor
John J. Purcell
By his Attorney
Franklin H. Hough

UNITED STATES PATENT OFFICE.

JOHN J. PURCELL, OF WASHINGTON, DISTRICT OF COLUMBIA, ASSIGNOR OF ONE-HALF TO WILLIAM H. ALLEN, OF SAME PLACE.

ELECTRIC COUPLING.

SPECIFICATION forming part of Letters Patent No. 486,027, dated December 13, 1892.

Application filed June 16, 1892. Serial No. 437,122. (No model.)

To all whom it may concern:

Be it known that I, JOHN J. PURCELL, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Electric Couplings; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

My invention relates to improvements in electric couplings, and especially to underground conductors in which access is had to the wires for the purpose of making splices when necessary, and while designed for this particular class of conductors I do not limit it to this use only, but regard myself as entitled to use it in connection with other forms of conductors for telegraph, telephone, or for lighting purposes where an electric current is used; but my invention is perfected, essentially, for the purpose of serving a long-felt want in connection with underground conductors, and by which means is provided whereby all air which is liable to contain moisture, and as a result produce a short circuit at the connections, is effectually excluded from the spliced joints.

A further object of my invention is to provide a coupling of the character described which shall be simple in construction, cheap, and of easy application to any size of cables; and the same consists in the novel adaptation and combination of parts, as will be hereinafter more fully described, and then specifically defined in the appended claims.

The invention is clearly illustrated in the accompanying drawings, which, with the letters of reference marked thereon, form a part of this specification, like letters of reference indicating like parts throughout the several views, in which—

Figure 1 is a side elevation of my invention, showing the coupling made with suitable housing over the spliced ends of the cable. Fig. 2 is a longitudinal vertical section of the same through the center of the coupling, and Fig. 3 is a detailed view of parts of the coupling.

Reference now being had to the details of the drawings by letter, A represents the ends of two cables, which when spliced are housed within the casing B, which is of a larger diameter than the cables, so as to allow the casing or tubing B to be readily slipped over the spliced portion, which is necessarily of a larger diameter after being spliced, the cable being made up of a number of small wires differing in number and size, as seen at D, Fig. 2.

On the inner surface of each end of the tubing B, I cut away the inner edge of the same, as shown at *b*, forming the shoulders *b'*, which recess is provided for the purpose of admitting the ring E, which has a smooth surface, so as to snugly set within it and be flush with the end of the tubing B. The ends of the tubing B are externally threaded to receive the threaded caps G, which caps are internally threaded.

H are rubber washers, which when the caps are screwed securely on the tubing are crowded inward and downward against the cable, thus forming an air or water tight contact.

I are screw-threaded plugs provided with the washers *i*, and when said plugs are screwed down against the washers and into the threaded apertures *i'* a water-tight joint is made.

K is an insulating compound, which is of any of the well-known insulating materials—as paraffine, asphaltum, rosin, ozocerite, tar, and the like—and when the insulating material used is in a normal condition of a semi-solid nature the same can be easily loosened from contact with the inner surface of the tubing when it is desired to slip the covering off from over the spliced portion by simply heating the outer surface of the tubing B.

The advantages of my invention will be readily seen by any person skilled in the art, as I provide means whereby any size of cable can be spliced by simply enlarging the tubing forming the housing, and by caps and washers correspondingly large or small having apertures which will snugly fit the cables to be spliced.

A further advantage of my coupler is in the fact that the cable can be spliced while under ground without making as large an excavation as is necessary with the couplings in common use, and in the construction of my coupling I use fewer parts than are ordinarily used in underground conductors.

Having thus described my invention, what I claim to be new, and desire to secure by Letters Patent, is—

1. In an underground-cable conductor, in combination, the spliced ends of a cable having a housing, having screw-threaded caps received directly onto the ends of said housing and having apertures conforming to the size of said cable, the screw-threaded plugs with suitable washers for forming a water-tight joint in the apertures i', and an insulating material covering the spliced ends of the said cable, substantially as shown and described.

2. In combination, in an underground conductor, of a spliced cable provided with a suitable housing consisting of a cylindrical tubing, the inner surface being recessed for a short distance from the ends, and provided with washers which are flush with the ends of said tubing, the rubber washers H, and the caps G, received directly onto the ends of said tubing, all substantially as shown and described.

3. The combination, with a spliced cable, of a housing over the spliced ends and formed at each end with exterior threads and interior shoulders, a ring E at each end of the housing, with its inner face bearing against said shoulder and its outer face flush with the outer end of the housing, the washer H over said rings and bearing against the ends of the housing, and the caps G, screwed on the ends of the housing and pressing the washer H against the ends of said housing, substantially as described, and for the purpose specified.

In testimony whereof I affix my signature in presence of two witnesses.

JOHN J. PURCELL.

Witnesses:
A. L. HOUGH,
FRANKLIN H. HOUGH.

PLAINTIFF'S EXHIBIT No. 6 D

406
305

No. 706,599. Patented Aug. 12, 1902

T. ROSATI.

ELECTRIC CABLE.

(Application filed Jan. 30, 1901.)

(No Model.)

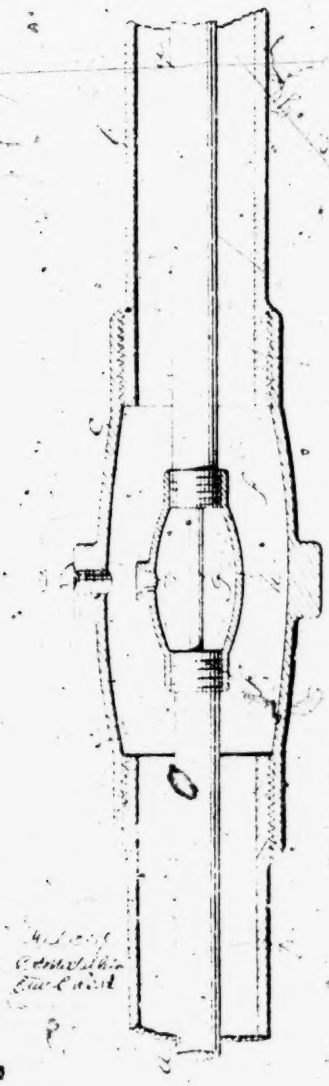


Fig. 1.

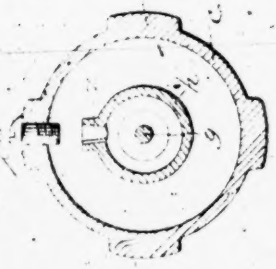


Fig. 3.

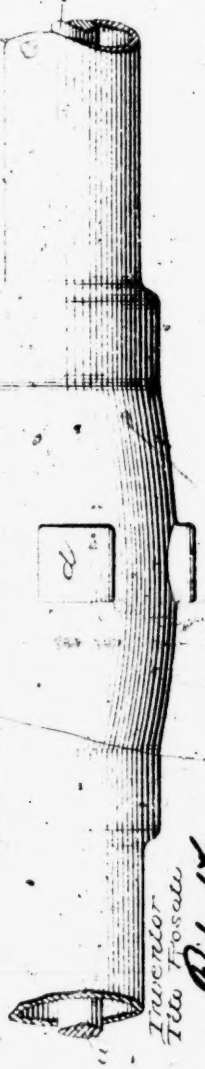


Fig. 2.

Witnesses:
Edward L. Wilkie
Chas. E. Foss

Inventor
Tito Rosati
by Richards & Co
Attys.

407
396

UNITED STATES PATENT OFFICE.

TITO ROSATI, OF FLORENCE, ITALY.

ELECTRIC CABLE.

SPECIFICATION forming part of Letters Patent No. 708,599, dated August 12, 1902.

Application filed January 30, 1901. Serial No. 45,386. (No model.)

To all whom it may concern:

Be it known that I, TITO ROSATI, a subject of the King of Italy, and a resident of Florence, Italy, have invented certain new and useful Improvements in Electric Cables, of which the following is a specification.

My invention relates more particularly to cables having surrounding sheaths or protectors; and the object of the invention is to provide an improved form of coupling for connecting the sections of the conductor and its encircling sheath or tube.

The invention is illustrated in the accompanying drawings, in which—

Figure 1 is a longitudinal section; Fig. 2, an elevation, and Fig. 2ª a cross-section.

In the drawings, *a* indicates the conductor, and *b* the sheath or protector, which consists of a metallic tube formed in sections corresponding approximately in number and length to the sections *a* of the conductor. The adjoining ends *f* of the conductor are threaded and are engaged by a small copper rod *g* and a tubular coupling-sleeve *h*, having its ends threaded to engage the ends of the conductor-sections. A large sleeve *c* encircles the inner sleeve and in like manner connects the adjoining ends of the tubes *b*. An opening is provided in this outer sleeve, closed by a screw plug *e*, and this opening alines with an opening *z* in the inner sleeve, through which a suitable filling material may be introduced.

I declare that what I claim is—

In combination an inner cable composed of sections, hollow coupling-sleeves connecting the ends of said sections and having an opening therein, tube-sections encircling said cable-sections and having couplings connecting the adjoining ends thereof, said outer coupling-sleeves having an opening alining with the opening in the inner coupling-sleeve and means for closing said opening, substantially as described.

In witness whereof I have hereunto set my hand in presence of two witnesses.

TITO ROSATI.

Witnesses:
EUGENIO BECCHINI,
SPIRITO BERNARD.

307

PLAINTIFF'S EXHIBIT No. 6E

409

398

No. [illegible] PATENTED MAY 26, 1908

P. S. VIELE.

CONNECTING CONDUCTOR FOR CABLES.

APPLICATION FILED AUG. 15, 1902. RENEWED MAR. 29, 1905.

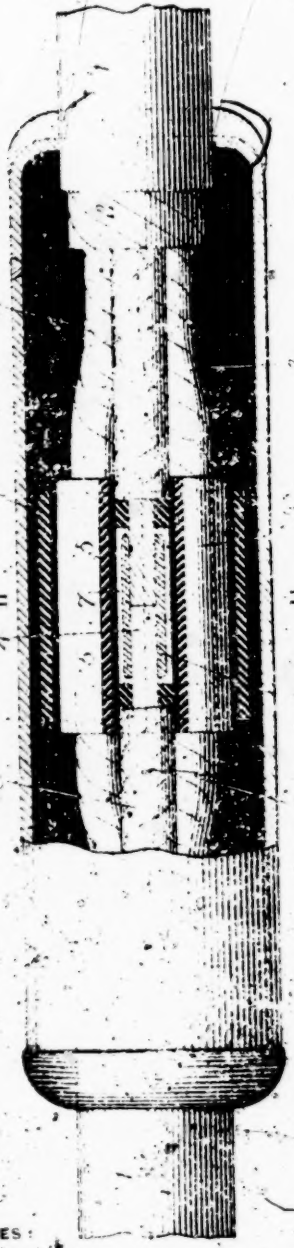


FIG. 1.

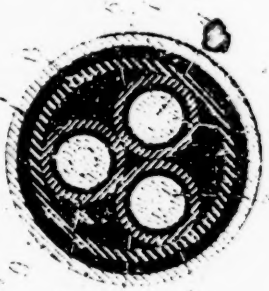


FIG. 2.

WITNESSES:
Herbert Smalley
F. E. Gardner

INVENTOR
Francis S. Viele
by Dawson & Wolcott Atty

UNITED STATES PATENT OFFICE.

FRANCIS S. VIELE, OF PITTSBURG, PENNSYLVANIA, ASSIGNOR TO STANDARD UNDERGROUND CABLE COMPANY, OF PITTSBURG, PENNSYLVANIA, A CORPORATION.

CONNECTING-CONDUCTOR FOR CABLES.

No. 888,374. Specification of Letters Patent. Patented May 26, 1908.

Application filed August 18, 1902. Serial No. 119,794. Renewed March 29, 1905. Serial No. 253,678.

To all whom it may concern:

Be it known that I, FRANCIS S. VIELÉ, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, a citizen of the United States, have invented or discovered certain new and useful Improvements in Connecting-Conductors for Cables, of which improvements the following is a specification.

The invention described herein relates to certain improvements in joints or splices for electric cables carrying high voltage currents. It has heretofore been the practice in making such splices or joints to remove the insulation from the sides of the conductors to be connected, a suitable distance, and then form an electric joint or union between these conductors in suitable manner. Insulation in the form of paper or fibrous tape was then applied by hand to the portions of the conductors, from which the insulation was removed. It is a matter of considerable difficulty to determine when a sufficient amount of tape has been applied to render the joint as strong electrically as the original insulation. As considerable care and labor are required in applying the tape, the workman is very liable to shirk it, and leave the joint imperfect. And further it is practically impossible to so apply the tape as to form a compact uniform thickness of insulation. The foregoing difficulties in applying and incident to the use of tapes in forming the insulation of joints are especially prominent when connecting the conductors of duplex and triple cable, as with such cable the conductor cannot be separated to any considerable extent and the tape has to be threaded between the conductors.

The object of the present invention is to provide for easy and quick formation of an insulating covering for the exposed ends of connected conductors of a uniform thickness and electrical strength which shall be at least equal to that of the original insulation.

The invention is hereinafter more fully described and claimed.

In the accompanying drawing forming a part of this specification, Figure 1 is a sectional elevation showing my improvement as employed in connecting the conductors of a triple cable, and Fig. 2 is a transverse section of the same on a plane indicated by the line II—II Fig. 1.

In the practice of my invention, the sheath 1 and covering 2 of the cable is removed a sufficient distance and the insulation 3 of the conductors 4 is also removed, as is customary. Sleeves 5 are then slipped over one of the ends of the conductors and pushed back far enough to permit of the ends of the conductors 4 being electrically connected. This connection may be formed in any suitable manner, as for example, by means of a metallic sleeve 6, soldered or sweated onto the ends of the conductor projecting into the sleeve, as shown. As the internal diameter of the sleeves 5 is made sufficiently large to slip over the insulation 3 of the conductors, there will be considerable space between the sleeve and the conductor when the sleeve is arranged over the joint, hence in order to hold the sleeve steady and form an internal support therefor, paper or fibrous tape 7 impregnated with insulating wax is wrapped a few times around the sleeve 6 and the exposed portions of the conductor, and plastic insulating material applied to the tape before the sleeve 5, which is made sufficiently long to overlap the insulation 3 on both sides of the point of union of the conductors, is slipped into position. The use of the tape and plastic insulating material is not necessary for insulating purposes, but it is preferred to employ them both as a centering support of the sleeve and also as a filling preventing air spaces within the sleeve.

After all the conductors have been connected and insulated, as described, the paper sleeves on the several conductors are pressed together and a large paper sleeve 8, which was slipped over one of the cables before any of the conductors were united, is slipped into position over the sleeves 5, as shown, and serves to hold all the parts of the cable. This binding sleeve is not necessary but is highly desirable as strengthening the joint. As is customary, a sheathing sleeve 9 is placed around the joint and connected to the sheath 1 of the cable, and liquid insulating material, preferably, is poured into this sleeve until all air is forced out and the sleeve completely filled.

The sleeves 5 in addition to forming an insulating covering for the joint, serve to hold the several conductors apart and afford spaces for the insulating material which is poured into the joint as described. In other

words the rigid sleeves 5 serve as spacing pieces to prevent contact between adjacent conductors, and hence if for any reason the sleeve did not extend from insulation to insulation, as for example, if it should slip from position, the efficiency of the joint would not be affected as the sleeve would prevent contact between conductors and the insulating material with which the joint is filled would afford sufficient insulation.

I am aware that thin light sleeves formed of non-conducting material, such as paper or indurated fiber, have been employed for insulating the joints of conductors carrying light currents for telegraphic and telephonic purposes. These sleeves are applied to conductors having their insulation formed of an air containing material, and are so constructed and arranged around the joint as to form an air pocket or cell similar to those forming parts of the insulation of the conductors, forming what is known as an unfilled splice or joint. While this manner of insulating joints is efficient for telegraph or telephone lines, which carry light or low voltage currents it is totally inefficient for conductors carrying high voltage currents, for the reason that sugh currents will pass between the sleeves and the insulation on the conductors. And further it is practically impossible to so form the joints that the air contained in the sleeves is dry, as is necessary to perfect insulation. In order to overcome these difficulties, the sleeve is formed so that its electrical strength is at least equal to that of the insulation on the conductors, and is made hard and rigid, so as to provide and maintain such position relative to the joint that the non-conducting filling applied as described between the sleeve and conductor, will have a uniform thickness. This sleeve is preferably formed of an absorbent material, as paper, and boiled in insulating material so as to be thoroughly impregnated therewith and thereby rendered as nearly as possible absolutely non-conducting.

I claim herein as my invention:

1. As a means for insulating joints in conductors for high voltage currents, a rigid integral sleeve of non-conducting material surrounding the splice between the conductors and forming the bridge or connection between the insulations on the connecting conductors, and having the space between the conductors and sleeve filled with non-conducting material, substantially as set forth.

2. A joint for cables having a plurality of conductors for high voltage currents, having in combination rigid sleeves of non-conducting material and overlapping the original insulation on the connected sections of the conductors, a similar sleeve surrounding the other sleeves, a sheathing sleeve and non-conducting material filling all the spaces within the sheathing sleeve, substantially as set forth.

3. A joint for cables having a plurality of conductors for high voltage currents, having in combination rigid paper sleeves impregnated with non-conducting material and overlapping the original insulation on the connected sections of the conductors, a similar sleeve surrounding the other sleeves, a sheathing sleeve and non-conducting material filling all the spaces within the sheathing sleeve, substantially as set forth.

4. A joint for cables having a plurality of conductors for high voltage currents having in combination rigid sleeves of non-conducting material surrounding the splices in the conductors, a similar sleeve surrounding the other sleeves a sheathing sleeve and non-conducting material filling all the spaces within the sheathing sleeve, substantially as set forth.

In testimony whereof, I have hereunto set my hand.

FRANCIS S. VIELÉ.

Witnesses:
F. F. McDONALD,
M. F. DIRNBERGER, Jr.

311

H. C. EGERTON.

ELECTRIC CABLE.

APPLICATION FILED FEB. 9, 1911.

1,073,596.

Patented Sept. 23, 1913.

3 SHEETS—SHEET 1.

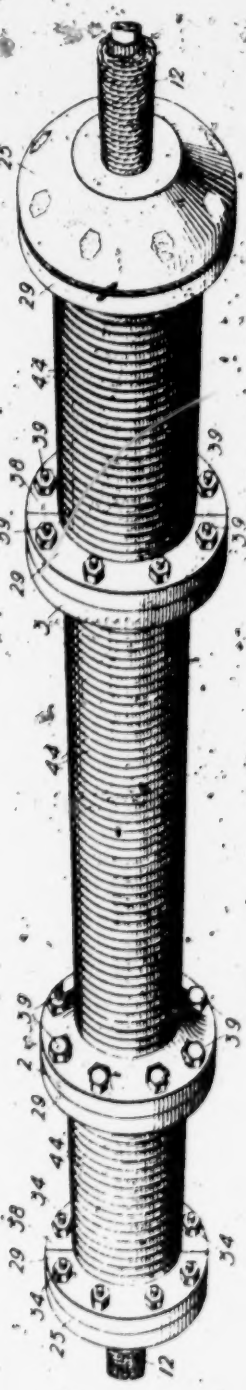


Fig. 1.

Witnesses:
C. M. Smith
Irving MacDonald

Inventor
Henry C. Egerton
by L. E. Skinner Atty

413 312

H. C. EGERTON.

ELECTRIC CABLE.

APPLICATION FILED FEB. 9, 1911.

1,073,596. Patented Sept. 23, 1913.

3 SHEETS-SHEET 2

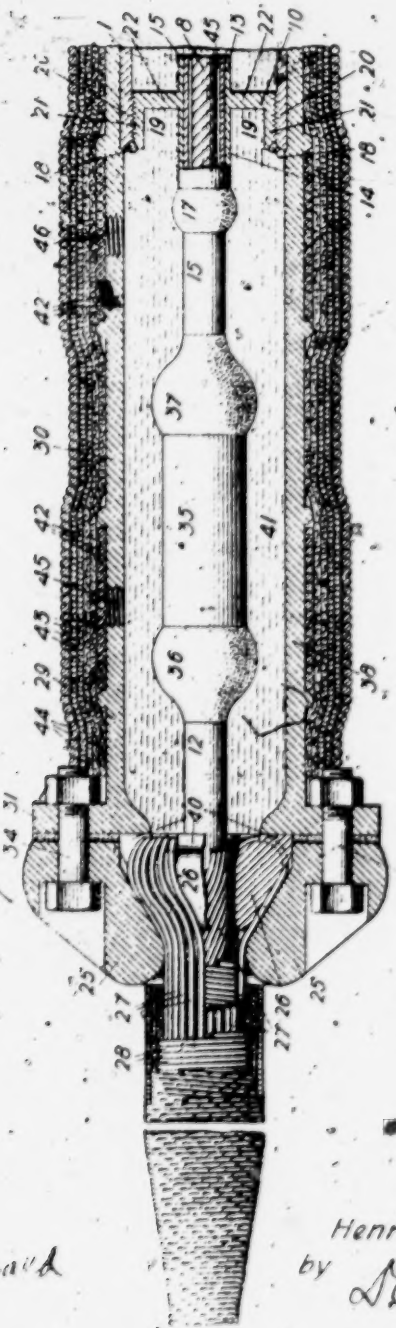


Fig. 2.

Witnesses.

Inventor:
Henry C. Egerton.
by D. Thurner, Atty.

313 414

H. C. EGERTON.

ELECTRIC CABLE.

APPLICATION FILED FEB. 9, 1911.

1,073,596. Patented Sept. 23, 1913.

3 SHEETS-SHEET 1.

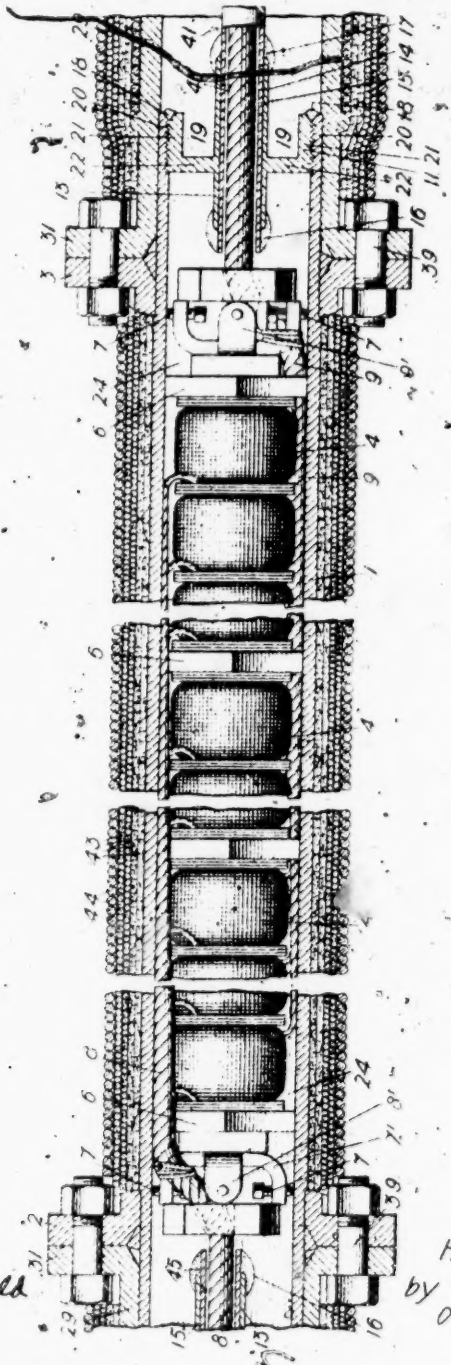


Fig 3.

Witnesses:
Irving MacDonald

Inventor:
Henry C. Egerton.
by D. C. Stewart Atty

UNITED STATES PATENT OFFICE.

HENRY C. EGERTON, OF RIDGEWOOD, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

ELECTRIC CABLE.

1,073,596. Specification of Letters Patent. Patented Sept. 23, 1913.

Application filed February 9, 1911. Serial No. 607,609.

To all whom it may concern:

Be it known that I, HENRY C. EGERTON, citizen of the United States, residing at Ridgewood, in the county of Bergen and State of New Jersey, have invented a certain new and useful Improvement in Electric Cables, of which the following is a full, clear, concise, and exact description.

This invention relates to submarine cables and more particularly to cables which are "loaded" in accordance with the well-known Pupin system. The loading coils may be assembled in substantial metallic protective cases and connected into the cable at intervals to form a part thereof.

It is the object of this invention in general to provide an improved construction for loading coil cases and for cable joints whereby the coils within the case or the cable conductors at the joints are protected from moisture and mechanical injury.

In accordance with one feature of the invention a junction member for uniting severed sections of the cable is made in the form of a pipe, preferably longitudinally split, and provided with devices for gripping or clamping the cable armor, together with means for securing these devices to the junction member. Such junction members may be used at each end of a loading coil case where they serve to protect the joints between stub ends of cable extending from the coil case and the main cable sections; or they may be used independently and in such use they serve to inclose and protect ordinary cable splices.

Another feature consists in the provision of specially formed end plugs which may be welded to the case after the coils and their connections are in place without danger of injury to any of the parts of the structure from heat.

In accordance with another feature of the invention the stubs formed of the cable leads extend respectively through short lengths of cable sheathing in the ends of the case, which sheathing is sufficiently greater in diameter than the inclosed stubs to provide annular passages for the entry of suitable moistureproof compound.

These and other features of the invention will be more particularly pointed out in the accompanying claims.

In the drawings—Figure 1 is a perspective view of the completed case inclosing the loading coils. Figs. 2 and 3 represent when placed together an enlarged longitudinal section of the left-hand portion of the completed case shown in Fig. 1, the part omitted being similar in all respects to the portion shown in Fig. 2.

The case 1 preferably consists of a length of heavy wrought iron pipe. A flange 2, 3 is preferably welded to the exterior of the pipe near each end. The loading coils 4 after being subjected to the various processes necessary to drive off moisture and prevent them from thereafter absorbing moisture, are slipped upon an axial support (not shown) which may be of wood, between blocks 6, also of wood, placed at intervals between the coils, the function of these blocks being to rest upon the interior face of the pipe and support the loading coils centrally within the case prior to the filling operation. Screws 7 in the legs 7′ of the spiders 8′, 9′ when tightened serve to maintain the structure rigid within the case. A twisted cable stub 8, 9 is associated with each end of the case and so connected with the coils 4 that the winding of each coil terminates in a pair of conductors in each cable stub. These stubs extend to the exterior of the case 1 at its ends through plugs 10, 11, respectively, for connection with the ends of the cable sections 12.

Each plug 10, 11 in the present embodiment is cylindrical in form and provided with exterior screw threads which engage with cooperating threads on the interior of the respective end of the case 1. The opening in the plugs 10, 11 through which the respective cable stubs 8, 9 pass is cylindrical in form and its walls are prolonged or extended for a considerable length in both directions as at 13, 14, providing a comparatively long channel within which a short length of lead cable sheath 15 is inserted and connected thereto at each end by carefully wiped joints 16, 17. Referring to the plug shown in Fig. 2, the periphery 21 extends to the left of the part 22, which I shall for convenience of description refer to as the plane of the plug, and this peripheral portion encircles the prolongation 14, these parts 21 and 14 forming in effect concentric circular walls closed at the inner end by the part 22 just mentioned, thus providing an annular recess 19 for a purpose hereinafter fully set forth. These plugs are each

preferably made of machine steel to avoid excessive electrolytic action attendant upon the use of brass or copper should the case be submerged in salt water, and the plug is wiped in two places 16, 17, as stated, to the sheath 15, one of which is outside and the other inside when the plug has been secured to the case 1, to materially reduce the liability of moisture entering the case 1 due to a single joint being imperfectly wiped, which liability is emphasized in a union with lead and steel. The plugs 10, 11 after having been threaded within the respective ends of the case are welded thereto. It is important that during this operation the heat incidental to the welding operation be confined to a very small region around the circumference 18 of the case 1 and not allowed to affect the lead sheath 15 and its wiped joints 16, 17, or the coils within the case. For this reason the plug is recessed as at 19 to enable the outside wiped joint 17 to be protected in any suitable manner, preferably by a water jacket, or asbestos sleeve slipped over the outwardly extending wall 14 and said splice, thus preventing the heat from radiating directly across, or the flame of the welding torch actually contacting with it, and to protect the inside wiped joint 16 and the lead sheath generally a water jacket may encircle the exterior surface 20 of the case 1, thus preventing the heat reaching the lead parts by conduction through the periphery 21 and connecting web 22 of the plug.

The loading coil cable stubs 8, 9 are of substantially smaller diameter than the lead sheaths 15 to provide a passage shown at 45 for a suitable moistureproof compound 24 which is allowed to flow in after the plugs 10, 11 have been welded to case 1. This or an equivalent construction is necessary, for the case must be welded before being completely filled with compound, for if the case were filled prior to the welding operation the heat incident thereto would boil the compound and the resultant gases would prevent a successful weld. The major portion of the case—that surrounding the coils 4—is, however, for convenience preferably filled before the plugs 10, 11 are attached, leaving the relatively smaller chambers immediately adjacent the plugs to be filled subsequent to the welding operation. The construction described moreover enables the air to be exhausted from the said chambers and the moistureproof compound allowed to flow in under the pressure of the atmosphere, which is a very desirable feature, since I am thereby enabled to totally fill the case with the compound, which would be impossible unless the air were exhausted due to the fact that the walls 13 of the passages, through which the compound flows, extend well into the case. This eliminates the possibility of moisture reaching the coils. In this condition the cases are shipped to the place of installation and during the process of laying the cable are interposed therein at predetermined intervals. A longitudinally-split metallic cylinder 30 is provided for each end of the containing case and is adapted to inclose and protect the splices 36, 37 between the projecting coil stubs and the respective cable sections and also to form a support for devices adapted to grip the cable armor, which is thus employed to take up mechanical strain and thereby protect the spliced joints and coil connections.

The operations incident to uniting one end of the case with the associated cable section, the other being similar, are as follows: A conical collar 25 and thimble 26 are slipped upon the section 12, the thimble being moved back on the cable a distance equal to the length of the cylinder 30 and the collar 25 a greater distance. The steel wires 27 which form the armor of the cable 12 are then stripped from the end of the section to this thimble, bent back over the same and securely lashed to the cable by a serving of galvanized steel wire 28. A portion of the lead sheath 15 protecting the loading coil stub 8 and of the sheath of the cable proper is cut away and the corresponding conductors spliced, a sleeve of lead 35 having been slipped over the cable end, which after the conductors are spliced is transferred to the spliced portion and secured thereover by a wiped joint 36, 37 at each side. The sections 29, 38 of the longitudinally-split cylinder 30 are then fitted to the case, making a telescopic joint therewith, the flange 31 coöperating with the flange 2 of the case and being secured thereto by bolts 39. The collar 25 is then moved over the thimble 26 and bolted at 31 to the cylinder 30. The tightening of bolts 34 forces the collar 25 toward the thimble 26 which in turn is held rigidly by four legs 40 bearing against the ends of the cylinder 30, thus securely clamping the armor wires 27 between the collar and thimble, the legs 40 providing between them curved surfaces, so that upon the tightening of the bolts 34, the armor wires are rigidly held between these curved surfaces and the coöperating curved surfaces of the inner part of the ring 25, thus saving them from abrasion. The chamber formed by the cylinder 30 is then filled with a moistureproof compound 41 through openings 45, 46 in the member 29, which may subsequently be stopped by plugs. The sections 29, 38 of the split cylinder 30 are then wound with steel wire 42 to afford greater rigidity. The entire structure may be served with some fibrous material shown at 43 and the whole thoroughly saturated with some waterproofing compound such as coal tar. As a further protection to this

waterproofing a serving of galvanized steel wire 44 is applied.

I claim:

1. In combination, sections of electric cable, sheathing and armor therefor, an envelop within which said sections are united, devices for engaging said armor, and clamping means for securing said devices to said envelop, said clamping means also causing said devices to grip said armor.

2. In combination, sections of electric cable, sheathing and armor therefor, a casing adapted to be associated with said cable, a thimble, a collar, and clamping means for securing said collar to said casing, said clamping means also causing the said collar and said thimble to grip said armor between them.

3. In combination, a junction-member, a collar secured thereto, and a thimble between said junction-member and collar, said thimble having feet which engage said junction-member, and curved surfaces between said feet.

4. The combination with an electric cable and the armor thereof, of a hollow metallic member associated with said cable, a thimble surrounding said cable and its armor, said armor being doubled back over said thimble and lashed to the cable, and a collar encircling said armor and thimble, and having a restricted neck, and means for securing said collar, and thereby said thimble and armor to said member.

In witness whereof, I hereunto subscribe my name this 7th day of February A. D., 1911.

HENRY C. EGERTON.

Witnesses:

IRVING MACDONALD,

MORGAN WASHBURN, Jr.

317

PLAINTIFF'S EXHIBIT No. 7

419

318

D. BROOKS.

Underground Telegraph Lines.

No. 165,535 Patented July 13, 1875.

Fig 1

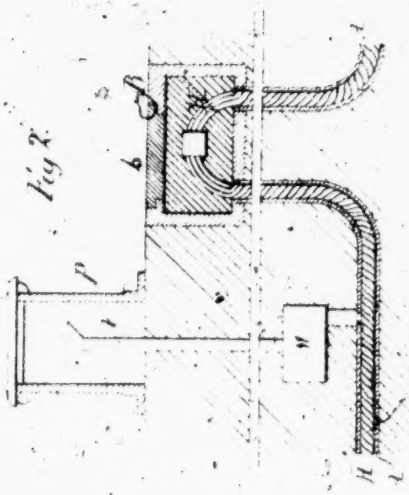


Fig 2.

Witnesses.

Harry Smith

Hubert Howson

Daniel Brooks

by his Attorneys,

Howson and Sons

UNITED STATES PATENT OFFICE.

DAVID BROOKS, OF PHILADELPHIA, PENNSYLVANIA.

IMPROVEMENT IN UNDERGROUND-TELEGRAPH LINES.

Specification forming part of Letters Patent No. **165,585**, dated July 13, 1875; application filed June 2, 1875.

To all whom it may concern:

Be it known that I, DAVID BROOKS, of Philadelphia, Pennsylvania, have invented an Improvement in Underground-Telegraph Conductors, of which the following is a specification:

The objects of my invention are to economically insulate underground telegraph wires or cables, and to afford facilities for ascertaining approximately the point or points where there is an imperfect insulation or defective continuity of current.

These objects I attain in the manner which I will now proceed to describe, reference being had to the accompanying drawing, in which—

Figure 1 is a vertical section of part of a street or roadway, showing my improvements; Fig. 2 being a section, drawn to an enlarged scale, of part of Fig. 1.

In carrying out my invention I first clothe a wire with cotton, hemp, jute, or other cheap absorbent material. I then insulate one or more of these covered wires by saturating them with melted paraffine, this insulation being perfect until the wire or wires are bent. The paraffine, however, when solidified, being a non-elastic substance, the bending of the wires fractures the covering, or makes therein an opening or openings, which admit air or moisture; and this impairs or destroys the insulation. In order to obviate this difficulty I place the covered wire or cable of wires in a tube, and maintain within the latter a constant supply of paraffine-oil, which, surrounding the wire or cable, enters the cracks and crevices of the wounded covering, and thus preserves the insulation.

In the drawing, A represents a light iron pipe, of sufficiently large internal diameter to freely admit the cable H, the pipe being in lengths screwed or otherwise connected together, length after length being pushed over the cable, which, with the pipe, is laid in the ground at such a depth below the surface as to prevent the paraffine coating of the wires from being affected by changes of temperature. I prefer to make the pipe in sections, as shown, each section being bent upward at each end, and each bent end terminating in a box, B, which is embedded in the ground, and has a detachable cover or lid, *b*. The wires of the cable, where the latter passes through the box from one section of pipe to another, are exposed by removing the fibrous covering, or by stretching the wires apart within the box, which is then filled with melted pitch or other equivalent insulating material or composition. The length of each section of pipe between its bent ends I propose to make equal to the length of a city block; but the length may be varied according to circumstances.

Whenever, on rare occasions, it has been ascertained that there is a defect in the insulation or conductivity of the cable, it is important that the point where the defect occurs should be determined, so that no more of the pipe need be dug up than the section which contains the defective portion of the cable. The section in which the defect occurs can be easily ascertained by so far removing the insulating packing in the box B as to expose the wires of the cable to which the test is applied. Another advantage of the boxes B is the facility which they afford of making branch connections with the main cable.

With each section of pipe communicates a reservoir, M, containing a supply of comparatively heavy paraffine-oil or liquid paraffine, the reservoir being situated so far below the ground that its contents cannot be affected by changes of temperature. This supply of liquid paraffine is maintained under pressure, so that it will surround the wire or cable, enter any crevices or cracks in the same, and thus preserve the insulation as well as supply any deficiency of the liquid paraffine which may occur in the pipes through leakage or otherwise. I prefer to maintain the desired pressure within the reservoir M by means of a stand-pipe, N, which extends from the said reservoir to a point above the surface of the roadway, and terminates within a casing, P. This stand-pipe contains a supply of paraffine-oil of a lighter character than that contained in the reservoir M, so that its fluidity cannot be affected by the low temperature to which it must necessarily be exposed during the winter months. The kind of light paraffine-oil thus maintained in the stand-pipe not only causes the contents of the reservoir M to continuously surround the cable, but effectually excludes from the latter all air and moisture which might otherwise impair the insulation of the wires of the said cable.

When through leakage the supply of liquid paraffine or heavy paraffine-oil in the reservoir M becomes diminished, the said reservoir may be replenished after first pumping the lighter paraffine-oil from the stand-pipe.

Although I have alluded to paraffine as a material wherewith to cover the cl[illegible]ed wire or cable, to liquid paraffine as a medium for neutralizing any defect in the insulation of the covered wire or cable, and to a column of lighter paraffine-oil as a means of maintaining a constant pressure of the heavier oil within the pipes, other materials may be employed for the same purposes; for instance, the covered wire or cable may be coated with rosin, or with a composition of which rosin forms a part, a heavy rosin-oil may be contained in the reservoir M and liquid turpentine in the stand-pipe, or pressure may be maintained within the reservoir M by other means than a column of liquid.

Whatever substance the reservoir M contains, it should be of such a character that it will have an affinity for and not be repelled by the coating of the covered wire or cable, so that it can effectually aid the coating in performing its insulating duties.

Without confining myself, therefore, to any specific coating for the covered wire or cable, or to any specific liquid insulating material or composition, I claim as my invention—

1. An underground telegraph wire or cable clothed with absorbent material, covered with insulating substance, and contained within a pipe, in combination with a liquid insulating medium maintained under pressure within the said pipe, all substantially as set forth.

2. An underground telegraph wire or cable surrounded by pipes arranged in sections, each section being bent upward at the ends, as set forth, and terminating in a box or receptacle, E, for the purpose specified.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

DAVID BROOKS.

Witnesses:
HUBERT HOWSON,
HARRY SMITH.

A.D. 1877, 19th DECEMBER. N° 4824.

Insulating Telegraph Wires, &c.

LETTERS PATENT to Bristow Hunt, of Serle Street, Lincoln's Inn, in the County of Middlesex, Gentleman, for the Invention of "IMPROVEMENTS IN INSULATING TELEGRAPH WIRES, AND IN PREPARING, AND LAYING, AND MAINTAINING INSULATED, SUBTERRANEOUS, AND SUBAQUEOUS TELEGRAPH CABLES." A communication from abroad by David Brooks, of Philadelphia, Pennsylvania, in the United States of America.

Sealed the 15th February 1878, and dated the 19th December 1877.

COMPLETE SPECIFICATION filed by the said Bristow Hunt at the Office of the Commissioners of Patents on the 19th December 1877.

BRISTOW HUNT, of Serle Street, Lincoln's Inn, in the County of Middlesex, Gentleman. "IMPROVEMENTS IN INSULATING TELEGRAPH WIRES, AND IN PREPARING AND LAYING, AND MAINTAINING INSULATED, SUBTERRANEOUS AND SUBAQUEOUS TELEGRAPH CABLES." A communication from abroad by David Brooks, of Philadelphia, Pennsylania, United States of America.

This Invention relates, firstly, to the insulation of telegraph wires clothed or covered with cotton or other fibrous material, the object being to perfectly insulate such wires.

In carrying out this feature of the Invention copper wires are preferred, and these are clothed or covered with cotton yarn by means of an ordinary wrapping, braiding, or plaiting machine. Other fibrous clothing or covering may be employed, but cotton is the cheapest, and serves the desired purpose well. A coil of this clothed wire is subjected in a suitable oven to a heat of about 300° to 320° Fahrenheit for an hour or an hour and a half, during which time all the moisture will be evaporated, and the gases generated by the exposure of the fibres to the heat will be evolved. While the coil is at about this temperature it is immersed either in melted paraffine or paraffine oil until the fibrous clothing or covering is thoroughly satu-

rated, after which the clothed wire will be ready for use. The preliminary heating of the textile covering reduces it to the best condition for that thorough absorption of the paraffine which ensures the best insulating effect.

Another mode of carrying this part of the Invention into effect is by heating a supply of paraffine or paraffine oil to about 300° or 320° Fahrenheit, and then immersing in it the coil of clothed wire without a preliminary heating thereof, the heat of the paraffine or paraffine oil being sufficient to expel all moisture and gases from the fibrous covering, which is consequently impregnated with the insulating material.

The Invention relates, secondly, to the preparation of telegraph cables to be laid under ground or under water.

A series of clothed or covered wires is collected together in a group, which is wrapped preferably with jute, hemp, or other coarse fibrous strands. The cable thus formed is placed in an oven and subjected to a temperature of about 300° to 320° Fahrenheit, and then immersed in paraffine oil; or the cable without preliminary heating is immersed in paraffine oil heated to the above degree. Two or more tubes of appropriate internal diameter, preferably ordinary lap-welded tubes of wrought iron, are coupled together so as to form a pipe fifty feet, or thereabouts, in length; this pipe is heated to such a degree that all moisture within it is expelled, and while both pipe and cable are hot the latter is introduced into the former, as shown in Figure 1 of the accompanying Sheet of Drawings, in which A represents part of the cable, to which is attached a wire B somewhat longer than the pipe G, so that when the wire has been pushed through the latter the projecting end can be seized and the wire used as a medium for pulling the cable through the pipe.

Figure 2 represents a pipe with cable enclosed ready for transportation, and for laying either under ground or under water.

After the cable has been introduced into the pipe G, one branch *a* of a T piece D is screwed on to one end of the said pipe, and to another branch *b* is screwed a short tube or cap E, which is furnished at the top with a detachable plug *e*, and the ends of the clothed or covered wires of the cable are turned up into this short tube, and a third branch *f* of the T piece is closed with a plug Z or otherwise, a short tube F closing the opposite end of the pipe, so that the cable shall be entirely enclosed, excepting at the plug hole of the short tube E, and through the plug hole is poured paraffine oil until all the interstices between the cable and pipe are filled, after which the said hole is closed by the plug *e*. The pipe is now ready to be transported with others to the place where the cable has to be laid.

The Invention relates, thirdly, to the mode of laying the cables described above.

The pipes G having been hauled to the trenches where they have to be laid, the tube F of one length is detached, thereby exposing a portion of the cable, the wires of which are then introduced into the T piece of the adjoining tube and turned upwards, so as to be adjacent to the turned up wires of the adjoining pipe, as shown in Figure 3; the two lengths are then screwed together, and the two sets of turned up wires twisted together metal to metal, the tube E being detached to allow of this; the twisted and exposed wires are then covered with a suitable fibrous wrapping, after which the short tube E is screwed into the T piece; this T piece, together with the portions of the pipe connected therewith, is then heated until all the moisture acquired by the fibrous wrapping during its exposure is evaporated, when paraffine oil is poured into the plug hole of the tube E, after which the said hole is closed.

The mode of laying the pipes under water is illustrated in Figure 4, where X represents the bed of a river or creek, and Y a barge, on which the pipes are coupled together in the manner described above, the barge being moved from time to time as pipe after pipe is added to the coupled pipes, and the latter sinking to the bed of the river as the barge recedes, the pipes being sufficiently elastic to permit this.

The Invention relates, fourthly, to the assured maintenance of the wires contained in the pipes in a perfectly insulated condition; this is effected by a series of

stand pipes M (Figure 5), which extend upwards above the ground, and communicate with the pipes G containing the wires, the upper ends of the stand pipes being furnished with detachable plugs, on removing which paraffine oil may be poured into them, so that a head of oil may always exist to ensure the penetration of the fluid-insulating material to all parts of the interior of the pipes, and prevent the access of moisture thereto; these stand pipes may be arranged about a mile apart, and they may communicate with elevated reservoirs.

Where a station occurs the flow of oil from the pipes into the station may be prevented by packing into the end of the pipes paraffine wax or other equivalent insulating material.

One stand may suffice for many miles of pipes containing the wires, providing it is placed at the highest portion of the line.

Other liquid insulating mediums besides paraffine oil may be used for maintaining the clothed wires in the pipes in a proper insulated condition, and air or gas continually maintained under pressure in the pipes may be used, providing always that the air or gas has first been deprived of its moisture by heat or chemical treatment.

Having now described the nature and objects of the said Invention, together with the manner in which the same is to be or may be performed or carried into practical effect, I would remark in conclusion that I claim as the Invention communicated to me by the above-named David Brooks,—

First. The mode, herein-before described, of insulating telegraph wires clothed or covered with fibrous wrapping, that is to say, heating the said wires to about from 300° to 320° Fahrenheit, and while at this heat immersing them in melted paraffine or paraffine oil.

Second. Insulating clothed telegraph wires by immersing them in paraffine or paraffine oil heated to a temperature of about from 300° to 320° Fahrenheit, substantially as herein-before described.

Third. The mode, herein-before described, of preparing a group of clothed or covered telegraph wires for underground or subaqueous use, that is to say, confining the group with suitable fibrous wrapping or covering, heating the wrapped group to about 300° to 320° Fahrenheit, or immersing it in paraffine oil heated to about that temperature, and then introducing it into a heated metal tube, all substantially as herein-before described.

Fourth. A telegraphic cable consisting of a series of coupled pipes containing a wrapped group of wires insulated with paraffine oil, substantially as herein-before described.

Fifth. A metal pipe containing one or more clothed or covered wires embedded in insulating material, and having projecting ends protected at one end of the pipe by a detachable tube, as herein-before described.

Sixth. A metal pipe containing a clothed wire or wires embedded in insulating material, and having at one end a T piece with detachable short tube, into which the wire or wires is or are turned, substantially as herein-before described.

Seventh. The mode, herein-before described, of coupling the said pipes together and connecting and insulating the connections of the wires in the said pipes, that is to say, twisting the wires together metal to metal, wrapping the twisted ends and protecting the same by a tube, into which fluid-insulating material is poured, substantially as herein-before described.

Eighth. The mode, herein-before described, of removing the moisture from the exposed portions of the clothed wires at the joint, that is to say, heating the said pipes and coupling at the joint to a temperature of about 300° Fahrenheit, and then applying the paraffine oil in the manner described.

Ninth. The mode, herein-before described, of laying the pipes containing the clothed or covered wire or wires under water, that is to say, sinking the coupled pipes, as section after section is added, in the manner substantially as set forth.

And, Tenth. The herein-before described mode of keeping the clothed or covered

wire or wires in the pipes in a constantly insulated condition by maintaining within the pipes and under pressure a supply of insulating fluid.

In witness whereof, I, the said Bristow Hunt, have hereunto set my hand and seal, this Nineteenth day of December, in the year of our Lord One thousand eight hundred and seventy-seven.

BRISTOW HUNT. (L.S.)

LONDON: Printed by George Edward Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office

1878.

FIG 1

FIG 2

FIG 3

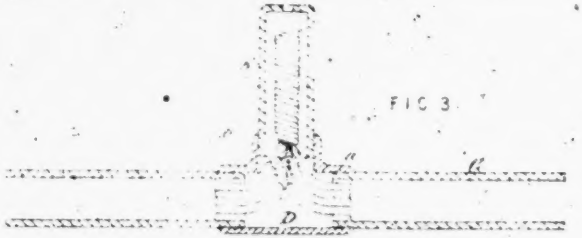
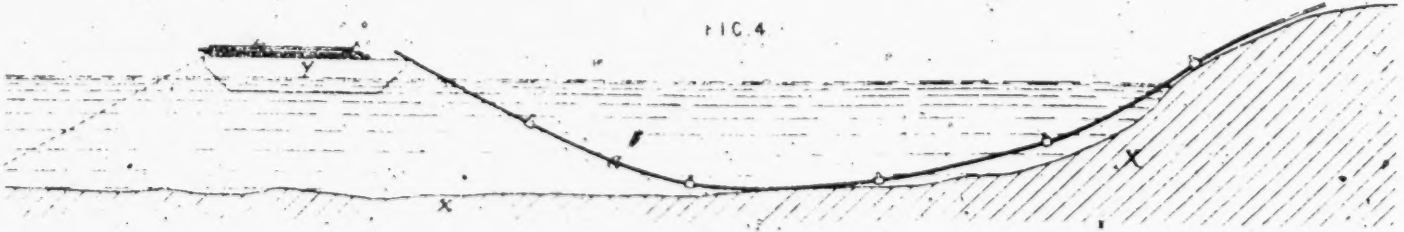


FIG 5

FIG 4



The third drawing is not shown

PLAINTIFF'S EXHIBIT, No. 7 B

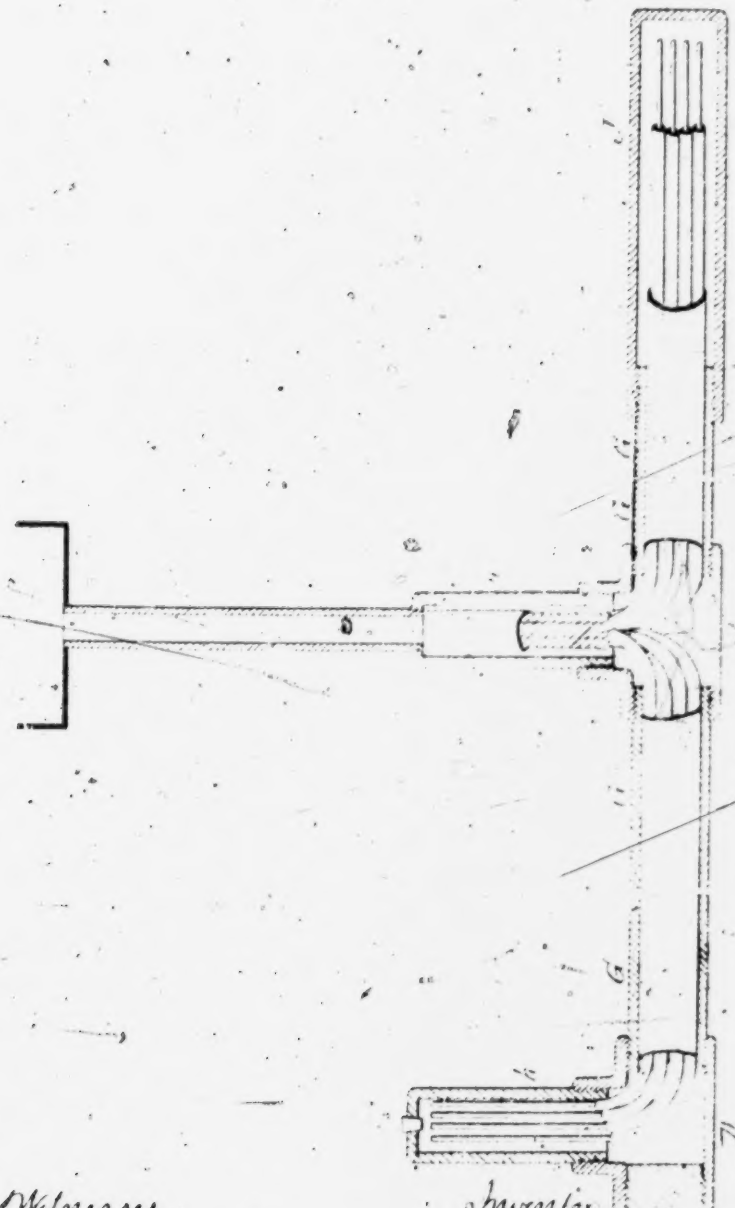
428

327

D. BROOKS.

Insulating Telegraphic-Conductors

No. 2 ,986. Patented Dec. 17, 1878.



Witnesses
Henry Howson Jr
Harry Smith

Inventor
David Brooks
by his Attorney
Howson and Sons

3328

UNITED STATES PATENT OFFICE.

DAVID BROOKS, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO THE BROOKS UNDERGROUND TELEGRAPH CONSTRUCTION COMPANY, (LIMITED,) OF SAME PLACE.

IMPROVEMENT IN INSULATING TELEGRAPHIC CONDUCTORS.

Specification forming part of Letters Patent No. **210,986**, dated December 17, 1878; application filed December 2, 1878.

To all whom it may concern:

Be it known that I, DAVID BROOKS, of Philadelphia, Pennsylvania, have invented a new and useful Improvement in Insulating Telegraph-Wires, of which the following is a specification:

My invention relates to an improvement in the mode of insulating telegraph-wires for which Letters Patent No. 165,535 were granted to me July 13, 1875, my present improvement consisting in keeping a clothed wire or wires contained in pipes in a constantly-insulated condition by maintaining within the said pipes, and under pressure, a supply of insulating liquid, which is in direct contact with the said clothed wire or wires, as explained hereinafter.

In carrying out my said patented invention, I first clothed a wire with cotton, hemp, jute, or other cheap absorbent material, and then insulated one or more of these clothed wires by saturating them with melted paraffine. I then [illegible] insulated wire or cable of wires in a pipe, and maintained within the pipe a constant supply of insulating oil.

I have ascertained that this preliminary insulation of the clothed wires with paraffine is essential to their complete insulation, and that if the fibrous material with which the wires are clothed be entirely deprived of moisture and gases in the first instance, ordinary petroleum and other liquids, after they are rendered anhydrous, may be used as insulating mediums, providing they are maintained in constant and intimate contact with the clothed wires.

The preliminary heating of the clothed wires or cable of wires may be effected in different ways. They may, for instance, be subjected in an oven to about 300° to 320° Fahrenheit for a sufficient length of time to insure the evaporation of all the moisture contained in the fibrous wrapping and the evolving of all the gases generated by subjecting the fibres to heat, and then (preferably while it is hot) steeping the cable in heated petroleum or other insulating liquid.

Another plan is to first steep the clothed wires or cable of wires in oil—petroleum or linseed oil, for instance—or other liquid which will not evaporate at a temperature of 350°, for the bath should be maintained at about that temperature. After this has been done the cable may be boiled in water in which chlorine or bleaching-powder has been dissolved, so that all traces of acids or gases may be removed. As the clothing of the wires is made somewhat tender by the above treatment, the cable may be wrapped with hemp, jute, or other cheap fibrous strands. The cable is then placed in a bath of any liquid insulating medium—common petroleum, for instance—the said bath being maintained at a temperature of about 230° Fahrenheit, and this steeping is continued until insulation ceases to increase. The cable, being now deprived of all moisture and gases and thoroughly insulated, is pulled through a pipe—an ordinary lap or butt welded iron tube, for instance—in doing which the fibrous clothing of the wires is protected by the above-mentioned wrapping.

Before the cable is pulled into the pipe the interior of the latter is deprived of all moisture. This may be done by heating the pipe or by introducing into it pulverized quicklime, which absorbs the moisture.

The manner of connecting the pipes containing the cables and maintaining the wrappings in a proper insulated condition after the pipes are laid will be best explained by reference to the accompanying drawing, in which—

G G represent the ends of two adjoining pipes, both containing cables similar to that above described. D is a T-piece, to which the pipes are secured, and into a branch, *h*, of this T-piece the ends of the wires of the cable in each pipe are turned up, after being deprived of the wrapping, so that they may be twisted together, metal to metal, after which the twisted wires are again securely wrapped with fibrous material and the branch *h* closed by a suitable screw plug or cap. Before the latter is tightly secured, however, I pour the liquid insulating material into the T-piece and branch, and apply heat to the same, so as to expel all moisture, after which the branch is closed by a screw-plug.

The cap at each end of the line of pipes should have a branch, through which the wires may be conveyed to the instrument or instruments at the station where they terminate; and there may be branches at intervals for the same purpose, these branches being filled with resin, pitch, or other solid insulating substance which will prevent the escape of the insulating-liquid. The fibrous wrapping and covering of the wires is thus maintained in a constantly-saturated condition, which insures complete insulation.

During transportation the projecting wires at one end of each pipe C may be protected by a cap, J, and the wires at the other end of said pipes turned up into the branch *h* of the T-piece, secured to said end, the third branch of the T-piece being closed by a plug, *m*.

The insulating-liquid to which I have referred above may be paraffine-oil, petroleum, or its products. I have ascertained, for instance, that refined petroleum, such as is employed for illuminating purposes, may be used. Even benzine may be employed; but this is not so perfect an insulating medium as refined oil when it is properly prepared.

Whatever liquid insulator be used, it is essential that it should be deprived of all water, which may be done by simply heating the liquid until all watery particles have evaporated.

The supply of liquid insulating material may be contained in any suitable reservoir or reservoirs communicating with one or more of the branches *h*, the reservoir or reservoirs being at such an altitude above the cable that the liquid insulating material therein will be under constant pressure, to secure the best insulation, and to effectually seal the interior of the pipes and protect the cable from moisture.

I claim as my invention

The mode herein described of maintaining a clothed wire or wires contained in pipes in an insulated condition by keeping the fibrous covering of the wires in the pipes constantly saturated with an insulating-liquid under pressure, as set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

DAVID BROOKS.

Witnesses:
ALEX. PATTERSON,
HARRY SMITH.

PLAINTIFF'S EXHIBIT No. 7 C

334

W. W. JACQUES.

Insulating Compound for Telegraph-Wires.

No. 227,168. Patented May 4, 1880.

Fig 1.

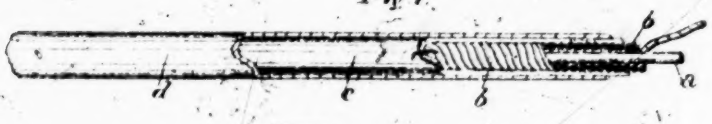


Fig 2.

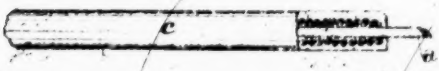


Fig 3.

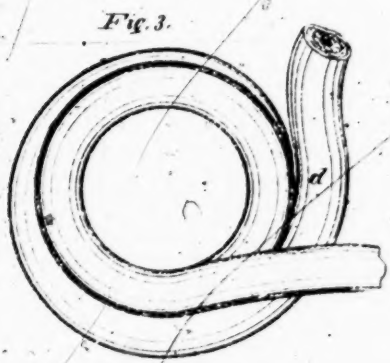


Fig 4

Witnesses:

Inventor:

William W Jacques
By his Atty
Chas B Mason

UNITED STATES PATENT OFFICE.

WILLIAM W. JACQUES, OF BALTIMORE, MARYLAND.

INSULATING COMPOUND FOR TELEGRAPH-WIRES.

SPECIFICATION forming part of Letters Patent No. 227,168, dated May 4, 1880.

Application filed September 24, 1879.

To all whom it may concern:

Be it known that I, WILLIAM W. JACQUES, of the city of Baltimore and State of Maryland, have invented a new and useful Improvement in Underground-Telegraph Wires, of which the following is a specification.

My invention has for its object to surround or inclose an electrical conducting substance, such as copper wire, with flexible insulating material having certain desirable characteristics, to wit: convenient to manipulate, not easily destructible, suitable to be laid directly in the earth, or in pipes, drains, &c., not affected by the ordinary elements or constituents of the soil, be repellant to water, not affected by heat or cold within the limits to which it would ordinarily be subjected, that while flexible it will not crack when bent short, and, further, be of such character that the several enumerated properties will not be lost or changed by time.

The invention consists in surrounding or enveloping a wire with some fibrous material, such as cotton, saturated with an insulating solution, in a warm state, of bees-wax and Venice turpentine.

In carrying out my invention I prefer to combine bees-wax, five parts, with Venice turpentine, two parts, which are properly incorporated by the aid of heat. The exact proportions named are, however, not essential, the only object being to attain such a consistency that it will neither harden with cold nor become liquid with heat within the limits of temperature to which it would ordinarily be subjected in the ground.

In the drawings hereto annexed, Figure 1 is a view of the underground wire, lead-incased, partly in section. Fig. 2 is a view of the insulated wire without the lead case. Fig. 3 illustrates the completed article coiled. Fig. 4 is a cross-section of same.

The letter *a* designates the wire; *b*, the fibrous material surrounding it. This material may be of any suitable kind, such as yarn or cotton cord lightly twisted, and is first saturated with the solution of bees-wax and Venice turpentine, and then wrapped regularly about the wire and cross-wrapped.

c represents the coating of the composition, which is applied over the aforesaid saturated fibrous material, and *d* the outer lead tube in which these parts are encased or sheathed, and which serves to protect the enveloping insulating material from the attacks of insects, or from puncture, cutting, or abrasion caused by contact with hard substances when the article is handled.

Thus constructed the wire is flexible, and adapted to be coiled or put on reels and otherwise handled in manner similar to ordinary wire.

I am aware that telegraph-wires have heretofore been wrapped or surrounded with cords or bands of fibrous material saturated or coated with insulating compounds, and also that such wires have been inclosed in pipes or tubes. I do not, therefore, claim such, broadly; but,

Having described my invention, I claim and desire to secure by United States Letters Patent—

1. A compound for insulating telegraph-wires, consisting of bees-wax and Venice turpentine, combined substantially as set forth.

2. The combination, substantially as set forth, of an electrical conducting-wire and an insulating compound consisting of bees-wax and Venice turpentine, combined substantially as described, surrounding the wire.

WILLIAM W. JACQUES.

Witnesses:
CHAS. B. MANN,
JNO. T. MADDOX.

PLAINTIFF'S EXHIBIT No. 7 D

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Date of Application, 2nd Sept., 1887
Complete Left, 31st May, 1888
Complete Accepted, 6th July, 1888

A.D. 1887, 2nd SEPTEMBER. N° 11,932.

PROVISIONAL SPECIFICATION.

[Communicated from abroad by THE FIRM OF SIEMENS & HALSKE, of 94, Markgrafen Strasse, Berlin, in the Empire of Germany, Electrical Engineers.]

Improved Means for Making and Insulating the Joints or Connections of Electrical Conducting Cables.

I, CHARLES DENTON ABEL of No. 28 Southampton Buildings, Chancery Lane, in the County of Middlesex, Consulting Engineer and Patent Agent, do hereby declare the nature of this invention to be as follows:—

This invention relates more particularly to establishing and insulating connections of electrical conducting cables having a central conductor insulated from an annular conductor or ring of conductors surrounding the same, whether such connections are for uniting two or more lengths of such cables with each other or for establishing branch conductors thereon.

The means employed for establishing such connections will be readily understood on reference to the accompanying drawings.

In the arrangement shown at Figs. 1 and 2, the several insulating and protecting coverings of the end of a cable are removed in a stepped form so as to expose a portion of the central and annular conductors.

The central conductor *a* is separated from the outer conductor *c* by a layer of insulating material *b*, the conductor *c* consisting of a number of conducting wires that are spun upon the coating *b*, *d* is the insulating coating between the outer conductor *c* and the lead sheathing *e*.

Upon the conductor *c* is in the first instance fitted the flanged metal sleeve *g* with the caoutchouc covering *f*, so that the ends of the wires *c* project to a certain extent beyond the flange of *g*: the wires *c* are then bent up radially, so that they lie against the flange, whereupon a second flanged sleeve *h* is fitted upon the insulating coating *b* and is secured by screws to the flange of *g*, so as to clamp the radial ends of the conducting wires between them, by which means a reliable mechanical and electric

[*Price* 11*d*.]

contact is established between the flanges and the conducting wires. The flange of *h* is provided with a pinching screw *k* for connecting another conductor with the flange and consequently with the wires *c*.

With cables whose central conductor consists of several wires, a metal socket *l* Fig. 2 is fitted over the end of the same, and is fixed by screws *m*. This socket has at its flattened end a pinching screw for attaching another conductor thereto, which is consequently also electrically connected to the central conductor *a*.

For protecting the insulating covering from the atmosphere, the connection is covered with a sheathing *q* of vulcanized caoutchouc enclosing the conductor *a* Fig. 1 or socket *l* Fig. 2, the insulated covering *b* and the sleeve *h*. The flanges of the sleeves *g* and *h* are also provided with a caoutchouc covering *o*, and the first named caoutchouc covering *f* encloses the sleeve *g*, the insulating covering *d* and the end of the lead sheathing *e*.

For connecting two lengths of the conducting cable above referred to, arrangements such as shewn at Figs. 3, 4, 5, and 6 are employed.

These consist of two sets of devices, the one set serving for establishing the electrical contacts, and the other for mechanically protecting the contact devices.

The two ends of the cables having been prepared in a similar manner to that above described, the two central conductors are connected by means of grooved metal clamps *r* and r^{I} secured together by the screw *t*. For connecting the two outer conductors there is placed upon each a plate S with central hole, and the wires of the conductors are bent up radially against the front face thereof, a second plate S^{I} is then fitted upon the insulating coating *b* and metal rods *p* with screwed ends having been passed through holes or slots in each of the four plates, each pair of plates is clamped together with the ends of the conducting wires between them by means of nuts X X upon the rods.

By this means a very secure connection is established on the one hand between the wires of the outer conductor and the plates, on the other hand between the plates S S^{I} nuts X and rods *p*, and the plates and wires of the outer conductor of the other cable.

In order to insulate and to protect these parts against injury, they are enclosed by a casing or sleeve formed of two parts A and B, which are constructed with openings at the ends for the reception of the cable ends.

In order to effect a tight joint between the two parts A and B, they are formed all round with external flanges having grooves *u* and u^{I} for the reception of packing material, and they are secured firmly together and to the cable ends by means of screws t^{II}. The upper part B has an inlet opening *y* closed by a screw plug Z, for filling the casing with insulating material.

This material may either be of a nature to solidify after being introduced in a liquid condition, or it may be permanently liquid, in which latter case it must however be specifically heavier than water in order that any water that may penetrate shall not mix with the insulating liquid, but rise to the surface thereof and thus leave the connections of the cables intact.

For connecting a branch cable to a main cable at any desired point, the arrangement shewn at Figs. 7 and 8 is employed. In this case the enclosing casing consists of a bottom part C connected to a middle part D by means of screw bolts t^{IV} and t^{IX}, having sockets E for the introduction of the main cable K and branch cable K^{I} the whole being closed by a cover F. The part of the main cable at which the junction with the branch cable is to be made and the end of the branch cable having been laid bare in stepped form, the wires of the outer conductors are bent up and clamped between plates S^{II} and S^{IV} in the manner already described.

The plates S^{IV} have upward projecting arms provided with pinching screws t^{V} at their upper ends, which rise to a certain height above the upper edge of the part D of the casing, and which serve to fix the connecting plate *v* for the two parts of the outer conductor of the main cable and the lead connection l^{I} for the branch cable.

The connection of the central conductor of the two parts of the main cable is effected

more layers each composed of 2 or more narrower sheets set side by side and with their edges close together and with the edges of the sheets in one set coming opposite to the centre of the sheets in the other set, might be used and be similarly wound on to the rods or tubes.

Or narrow strips might by similar apparatus be wound on spirally and made to break joint with one another.

After completing the winding of the sheets or strips of paper as above to any desired thickness, an additional layer of paper, tape or any suitable material may be wound on in sections or spirally to prevent the other sheets or strips from unwinding on removing the covered rod or tube from the trough or groove.

The conductors of concentric mains such as described in my former Patent No. 15251 in the year 1885 may be insulated in the same way.

Cloth, cotton, hemp, or other fabric might be used instead of paper as a medium for holding the insulating material.

In place of saturating the paper or other fabric with the insulating material only at the same time that it is being wound on to the rod or tube the paper or other fabric might be first saturated with the insulating material and be compressed between rollers or other suitable gear so as to ensure that each part shall be thoroughly saturated and to close up any flaws or bubbles that there may be in the insulating material and be afterwards wound on to the conductors in a similar manner to that above described, with or without again passing it through the liquid insulation.

The comparatively rigid rod or tube, covered by any of the aforesaid methods, is then inserted bodily into the interior of another tube, the sectional area of which is preferably equal to that of the former rod or tube, and the internal diameter of which is slightly greater than the external diameter of the covered rod or tube, and in order to compress this outer tube firmly on to the insulation of the inner tube, I cause the entire length of the main so formed, to pass through a die, or equivalent thereof, of diameter smaller than the outer diameter of the outer tube. This I do by means of an ordinary draw bench, rolling mill, or by compression by hydraulics, steam or compressed air &c., or other known method.

The concentric electric main so formed can then be again covered on the outside with insulation by any of the methods aforesaid and when covered be again bodily inserted into another tube preferably of iron, which latter tube can be compressed on to the inner tube as aforesaid.

The outer iron tube is then coated with any anti-corrosive mixture, to prevent oxidation &c. as this is usually laid into the ground without other external protection.

In addition to the above methods of insulating the rod or tube I arrange in some instances to fill the interior of the inner tubes when jointed and laid with a heavy oil, wax, or other suitable insulating material which may be kept under a heavy head or pressure for the purpose of filling up any flaws in the insulating material.

Or I may apply such a head or pressure to the insulation portion of the cable only, with or without suitable insulation containers or receivers.

Or I may keep the entire cable under a head or pressure as above described.

Dated this 15th day of October 1889.

CARPMAEL & Co.,
Agents.

COMPLETE SPECIFICATION.

Improvements in Electrical Mains and in their Manufacture.

I, SEBASTIAN ZIANI DE FERRANTI of 120 Fellows Road, Hampstead in the County of Middlesex, Electrician, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement :—

My improvements relate to the insulation of electrical conductors which are made in short lengths of comparatively rigid rods or tubes coupled together end to end by suitable couplings.

In order to insulate the several lengths of the rods or tubes I wind around each length a sheet or sheets of paper soaked in an insulating material say for example melted paraffin and this I do by rotating the rod or tube and causing it to wind the paper around itself. I use sheets of paper each of a length equal to the length of the rod or tube to be covered and of any convenient width so that when wound on to the rod or tube the several layers of paper may be complete in themselves and uniform insulation be obtained throughout the length of the rod or tube.

To wind on the paper I preferably place the rod or tube in a V or other conveniently shaped groove or trough capable of holding, or of being submerged in, an insulating material, liquid or liquid when hot and I cause one or more weights such as rollers to bear upon the tube or rod at or near its top and along the whole or a portion of its length. A sheet of paper is laid on to a table at one side of the trough or groove and one edge of it which is of a length equal to the length of the rod or tube to be covered is led below the rod or tube and between it and the trough or groove and then upwards and between it and the weights or roller. The liquid insulation is then made to more or less fill the trough or groove and the rod or tube is turned in such a direction as to wind on the paper.

Figure 1 of the drawings hereunto annexed is a side elevation,

Figure 2 a vertical cross section and

Figure 3 a plan of apparatus constructed as I prefer for covering electric conductors in the above manner.

The machine is composed of 4 box castings A which are bolted together to form one continuous length rather longer than the length of the main to be covered. These are closed on the top and two sides, but are open at the bottom, the top forming a trough in which the paraffin or other material used for insulation can be heated if desired and retained. Standing up from the bottom of this trough is a projection B having a V shaped recess B^1 formed along it at the top. In this V recess is placed the conductor C which is to be covered. E is a table supported on arms or brackets D which are fixed to the front of the castings A. The table is free to be racked in or out by the shaft F carrying a pinion that gears into a rack G. On the table is placed the sheet of paper that is to be wound on to the conductor.

At the back of the machine are also brackets H which support a shaft K which gives the necessary turning motion to the conductor when the latter is being covered. The shaft K is driven from a pulley Y which is loose upon it and which is itself driven at a constant speed. The pulley can by a fork entering a groove formed around its hollow axis be moved endwise on the shaft K and pressed against a disc Z which is fixed to the shaft and so drive the shaft by friction.

Movement may be given to the fork from a treadle at the end of the machine or in other suitable ways. At each end of the shaft is fixed a small sprocket wheel A^1 on either side of each sprocket wheel is an arm or strap B^1 which is free to turn around the shaft. At the upper end of the straps which are on either side of each sprocket wheel is carried a sprocket wheel D^1 of larger diameter and this is driven by an endless chain from the sprocket wheel A^1. The lower ends of the arms carry a weight C^1 to balance the weight of the parts which are carried by the upper ends of the arms. A shaft E^1 which is provided with a continuous key way passes through the centre of the sprocket wheel D^1. At one end it carries a hand wheel F^1 which is free to turn on the shaft but is held from moving endwise of the shaft by the shoulder G^1 and lock nut H^1—at the other end it carries a gear wheel K^1 and also two straps L^1 loose upon it and one on either side of the gear wheel—these straps at their lower end carry another wheel M^1 into which the wheel K^1 gears.

The spindle of the wheel M^1 is at one end bored out to form a socket to receive and hold a stem projecting from a plug that is driven into the end of the tubular conductor that is to be coated. The plug may have sharp edged ratchet like teeth formed along its sides so that when driven into the end of a tubular conductor it shall not be able to revolve therein.

When a conductor with a plug secured in each of its ends is placed into the

solid end piece *s* has a screw *u* for attaching a conductor thereto and connecting it with the said central conductor. Over this tube *r* is wound the band *o* of insulating-tape referred to in Fig. 1, and which also covers the insulating-layer *b* and tube *h*, while the remaining parts are similar to those shown in Fig. 1.

To connect two cables of the kind described with each other, we use the arrangement shown in Figs. 3, 4, and 5, and to protect the joint the protective box or casing shown therein is used. This box consists of two flanged halves *v* and *w*, adapted to be fastened together by screws or bolts *x' x'*, the upper half *v* of the box having an upward extension *y*, in which is a plug *z*, provided with a screw-thread, and which may be removed to fill the box with insulating material. Into this box the cable ends, which have had the several layers thereof cut into steps, as described, and provided with the flanged tubes *f* and *h*, are introduced, the concentric conductors thereof being united by rods A, having screw-threads upon their ends adapted to receive two pairs of nuts B B, by which means the flanges *g* and *i* are drawn together, thus dispensing with the screws *j* and *m*.

To connect the central conductors of the cables with each other, two grooved metal blocks C are used, between which the uncovered end of the said conductor is placed and the blocks firmly drawn together by means of a screw D.

The cable ends may be introduced into the box in any manner that will make the introduction thereof hermetical, and the flanged halves of the box may be also provided with means for making their connection water-tight.

For uniting three cables meeting at a certain point with one another and protecting their joint, the apparatus is used illustrated in Fig. 6. The protective casing is similar to that shown in Figs. 3, 4, and 5, except that it has a side or lateral extension to receive the extra cable.

Curved rods E E connect the flanges of the tubes on the cable with each other, while the blocks C receive an extra groove for the central cable.

When it is desired to connect in series a branch cable with a main throughgoing one, the flanges *g i* on one end F of the maingoing cable are connected to the flanges *g i* on the branch cable G by means of the curved rod E, having nuts upon its ends, while the central conductors of the said throughgoing cable are united by the grooved blocks C. The central conductor of the branch cable is connected to the concentric conductor of the end H of the throughgoing cable by means of the flat-pointed screw-spindle I, connector J, and screw K.

Having now described our invention, what we claim, and desire to secure by Letters Patent, is—

1. In a coupling for cables having a concentric wire conductor wound around a layer of insulating material, the combination of two flanged tubes, one of the said tubes being shoved upon the said conductor and the other upon the insulating material, means for drawing the flanges thereon together, and a clamping-screw adapted to receive a conductor, as and for the purpose described.

2. In a coupler for cables having a central conductor separated from a conductor concentric therewith by a layer of insulating material, the combination of two tubes provided with flanges, one of the said tubes being shoved upon the concentric copper conductor and the other upon the insulating-layer, means for drawing the said flanges together, and a ribbon of insulating material wound around the said parts, as and for the purpose described.

3. In a coupling for the electrical connection of cables having concentric conductors, the combination of two flanged tubes upon each cable and conducting-rods having threads upon their ends for the reception of nuts, whereby the said tubes on each cable may be drawn together and the cables connected with each other, as and for the purpose described.

4. In a coupling for the electrical connection of cables having a central conductor insulated from conductors concentric therewith by a layer of insulating material, the combination of two grooved metal blocks, means for drawing the said blocks together, whereby the central conductors are connected with each other, two flanged tubes upon each cable, and conducting-rods having threads upon their ends for the reception of nuts, whereby the tubes on each cable may be drawn together and the cables connected with each other, as and for the purpose described.

5. In a coupling for the connection in series of a branch cable having a central conductor separated from a conductor concentric therewith by a layer of insulating material with a like main throughgoing cable, the combination of grooved metal blocks for the reception of the ends of the said central conductor of the main cable, two tubes provided with flanges upon each of the said cables, conducting-rods adapted to connect the said tubes upon one end of the main cable with the tubes upon the branch conductor and means for connecting the central cable of the said branch cable with the tubes upon the other end of the main cable, as and for the purpose described.

In testimony that we claim the foregoing we have hereunto set our hands this 20th day of December, 1886.

BROR HEMMING WESSLAU.
GEORG TRAUTWEIN.

Witnesses:
B. ROI,
M. W. MOORE.

PLAINTIFF'S EXHIBIT No. 7 G

UNITED STATES PATENT OFFICE.

DORRIS WHIPPLE, OF NEW YORK, N. Y., ASSIGNOR TO STANDARD CHEMICAL COMPANY, OF BAYONNE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

RESINOUS COMPOUND.

1,083,170. Specification of Letters Patent. Patented Dec. 30, 1913.

No Drawing. Application filed November 6, 1909. Serial No. 526,666.

To all whom it may concern:

Be it known that I, DORRIS WHIPPLE, citizen of the United States, residing at New York, in the county of New York and State of New York, have invented new and useful Improvements in Resinous Compounds, of which the following is a specification.

In companion applications, Serial Numbers 526,660, 526,661, 526,663 and 526,664, filed of even date herewith, are described a new resinous compound in the form of soft, non-oxidizing, non-drying, permanently plastic mass of very high electrical resistivity, and a new resinous derivative in the form of a limpid, oxygenated oil, which is permanently fluid, incapable of further oxidization, and possesses a high electric resistance factor. Each of said products is admirably adapted as an insulating medium for electrical cables and the like, and it is found that a combination of the two new products, which for convenience is designated insuline resin, and insuline oil, respectively, is especially well adapted as an insulating medium in cases where the high fluidity of the oil alone on one hand, and the gummy character of the resin on the other would render the application of the products individually unsatisfactory.

The present invention therefore contemplates the provision of an insulating compound including both insuline resin and insuline oil with or without additional ingredients.

To produce the insuline resin, any resin which consists essentially of abietic anhydrid or abietic acid, preferably rosin, is heated in an iron still to a temperature of approximately 135° C., and the molten mass blown with moist air for the purpose of oxidizing the abietic acid until the contents of the still show a high percentage of tetra-abietic acid. After the foregoing operation has been conducted for the necessary period of time, determined by the specific tests described in my applications aforesaid, the temperature of the mass in the still is raised to approximately 140° C., and dry air is passed through the mass for the purpose of expelling any uncombined watery vapor resulting from the previous operation and to effect a further oxidization of the abietic acid. After the conclusion of this operation the resultant product is my improved insuline resin, which is in the form of a soft, gummy material, having a specific gravity of .98, which melts at a temperature about 20° C., lower than the melting point of the rosin from which it was made, which is less soluble in petroleum spirits than rosin and is freely soluble in petroleum oils, is non-drying, is incapable of further oxidization, and retains its soft and plastic condition indefinitely; is free from carbonaceous particles and contains no rosin oil, no pinene derivatives, and no volatile organic acids.

To produce insuline oil, rosin in appropriate quantities is heated in an iron still to a temperature of 150° to 200° C., and until the distillate begins to show the presence of resin or resin hydrocarbons. The temperature is then raised to substantially 250° C., and air which has been saturated with watery vapor at approximately 100° C., is passed through the heated mass in the still to drive off any remaining volatile constituents and to furnish the necessary oxygen or hydroxyl groups to the resin. The cover of the still is then tightly fitted and the temperature raised to approximately 360° C. to break up the oxygenated resin into lower homologues which constitute oxygenated resin oil. The distillate from this operation is again introduced into the still and blown with dry air at a temperature of approximately 150° C., to drive off the turpentine products resulting from the next preceding operation, which effect is indicated by the absence of turpentine oils or vapors in the distillate. The residual oil is now subjected to a temperature of approximately 320° C., and the first portion of the distillate is rejected, while the remaining portion is collected and the distillation carried on until the carbonization point is reached. This final distillate is the new insuline oil, which is found to be an oxygenated resin oil, to wit: a saturated oil having all its bonds satisfied or saturated with hydroxyl or oxygen, which is incapable of further oxidization under any conditions of heat, light, and moisture that are encountered when the material is applied to the purposes for which it is intended, is non-drying, limpid and slightly fluorescent in appearance; cannot be saponified, is miscible with petroleum oils, and possesses an electrical resistance capacity at least twice as great as the best resin oil or vegetable oils.

By mixing regulable portions of insuline

V groove B the sockets in the spindles of the wheels M^1 are made to pass on to the stems of the plugs by moving the shafts E^1 endwise by the hand wheels F^1 which are upon them and when the shaft K is rotated the conductor which is to be coated will also be rotated. Other means than that above described might be adopted for connecting the ends of the conductor which is to be covered with the pulleys by which the conductor is to be rotated.

O O are rollers covered with india rubber these rest upon the top of the paper which is on the table E and keep it from creasing—they also serve to put a certain amount of tension on the paper.

L L are arms on standards rising up from the bottom of the trough. Q is a bar of H iron held to the vertical front faces of the standard by straps T which allow of the bar being raised or lowered. The bar Q has bolted to it brackets U to which are hinged arms V which at their ends embrace the axes of the rollers O. The standards L at the top also carry a shaft M on which are three arms N from which chains W descend to links X for raising the rollers O. Other chains from the shaft M also raise or lower the bar Q.

S is a roller resting upon the top of the conductor which is to be coated. This roller may be in three or more sections to give flexibility, it is embraced and kept in place by a number of two pronged forks R which descend from the bar Q. The extremities of the two prongs of the forks extend to a short distance below the central axis of the roller S and below the central axis they are bent inwards towards one another so that the space between them is less than the diameter of the roller. Consequently when the forks are raised they carry up with them the roller S.

The axis M has an arm or hand wheel upon it by which it can be turned whenever the rollers O and S are to be raised. When the axis is free the rollers descend until the roller S rests upon the conductor.

R^1 are weights carried by chains from a shaft N^1 so that they can be raised or lowered. When they are lowered and immersed in the melted paraffin the surface level of the paraffin rises until the paraffin flows over the top of the projection B into the V recess B^1. When the weights are raised up the surface level of the paraffin is lowered until it is below the bottom of this recess. When the level is so lowered a coated conductor can readily be raised up out of the V groove and taken away and another conductor to be coated put into its place.

The shaft N^1 can be turned to raise or lower the weights R^1 by a worm wheel upon it into which gears a worm P^1 on a shaft which can be turned by a hand wheel Q^1. The operation of the machine is as follows:—A sheet of paper of the same length as the conductor which is to be coated is laid upon the table E. The conductor is also laid along the table and the edge of the paper is secured to it preferably by shellac solution.

The conductor is then laid into the V groove B^1 and its ends coupled to the pinions M^1 as above explained. The rollers O and S are then lowered and the pinions M^1 made to revolve to cause the paper to be wound up on to the conductor. As the paper is being wound up another sheet of paper is laid on to the table and made to overlap and adhere to the first sheet and so the winding goes on until the requisite thickness of coating is attained.

When working with sheets of paper that have already been coated with paraffin the pressure of the rollers O upon the overlapping sheets is sufficient to cause them to adhere to one another—in other cases I may attach the new sheet of paper to the partially wound one by means of shellac, shellac varnish, or other suitable gum, wax, or adhesive mixture, applied along the whole or a portion of the edge of one or both sheets of paper, or cause them to adhere in other suitable ways.

In place of each sheet of paper being of the same length as the rod or tube two or more layers each composed of two or more narrower sheets set side by side and with their edges close together and with the edges of the sheets in one set coming opposite to the centre of the sheets in the other set, might be used and be similarly wound on to the rods or tubes.

Or narrow strips might by similar apparatus be wound on spirally. To do this

the strips might be carried by bobbins and the bobbins be caused to traverse slightly in a direction endwise of the conductor at the same time that the conductor was rotated to wind the strips around itself. In this way the ends of the section of the covering formed by each strip would be coned one end convex and the other concave and the convex end of one section would enter the concave end of the next section as shewn in the diagram Figure 4.

Similarly the ends of the whole covering on each conductor would be coned one end convex the other concave and when coupling together two lengths of conductor the convex end of the insulation on one length would enter the concave end of the insulation on the next length so that the joint between them would be inclined to the conductors in place of at right angles to them.

When the insulating covering is about ½ an inch in thickness the coned ends may conveniently be about 6 inches in length. Each joint therefore in the insulating covering is a long sloping joint instead of a short one at right angles to the conductors so that in case of any defect in the union of the end of one length of the insulation to the end of the next—the distance a spark would have to travel to pass through the insulation would be of considerable length and so perfect insulation is ensured.

If two or more layers of strips are wound on to the conductors at the same time then the coned junctions in one layer may be intermediate of the coned junctions of the next layer as shewn in the diagram Figure 5.

Or strips of paper or fabric of the same length as the conductor might be used in which case the ends of the covering of insulation would be coned in the manner above described.

It is not necessary that the strips should be wound on spirally to obtain these coned ends to the covering of insulation the same result may be obtained in other ways as for example the conductors may first be covered with a uniform cylindrical covering and the ends be afterwards turned down in a lathe. In this way the edge of the paper would be made to wind in a slow spiral around the conductor just as though the strip had been wound on spirally.

Similar coned ends might also be obtained by using a knife to cut each edge of the paper as it is being wound on to the conductor, a slow traversing movement being given to the knives in a direction endwise of the conductor as the winding goes on. In this way the edges of the strips would similarly be made to wind in slow spirals around the conductor.

Other ways of forming the cones might also be adopted so long as when the paper is unwound from the conductor its edge is inclined to the main and not at right angles to it.

After completing the winding of the sheets or strips of paper as above to any desired thickness, an additional layer of paper, tape or any suitable material may be wound on spirally to prevent the other sheets or strips from unwinding or removing the covered rod or tube from the trough or groove.

Cloth, cotton, hemp, or other fabric might be used instead of or in combination with paper as a medium for holding the insulating material.

In place of saturating the paper or other fabric with the insulating material only at the same time that it is being wound on to the rod or tube the paper or other fabric might be first saturated with the insulating material and it might be compressed between rollers or other suitable gear so as to ensure that each part shall be thoroughly saturated and to close up any flaws or bubbles that there may be in the insulating material and be afterwards wound on to the conductors in a similar manner to that above described, with or without again passing it through the liquid insulation.

In practice I find it preferable to use paper so treated, passing it again through the liquid insulation when winding it.

To first saturate the paper with paraffin or like material I first cause it to travel over heated cylinders or plates so as to dry it and then cause it to pass down into a trough containing the melted insulating material and around a roller immersed in

this material and then lead the paper up out of the bath and over rollers until it is sufficiently cool to allow of its being wound into rolls.

It must be understood that the paper, cloth, cotton or other fabric employed is of pure or comparatively pure material and contains no substance or chemical that will conduct electricity, further the paper or other fabric must be entirely free from moisture, and this I achieve by passing the material slowly over revolving steam heated cylinders, over heated iron plates, or by other well known methods as above described.

The comparatively rigid rod or tube, covered by any of the aforesaid methods, is then inserted bodily into the interior of another tube, the sectional area of which is preferably equal to that of the former rod or tube, and the internal diameter of which is slightly greater than the external diameter of the covered rod or tube, and in order to compress this outer tube firmly on to the insulation of the inner tube to prevent the inner covered rod or tube from separating or slipping away from the outer tube I cause the entire length of the main so formed, to pass through a die, or equivalent thereof, of diameter smaller than the outer diameter of the outer tube. This I do by means of an ordinary draw bench or rolling mill or other known method.

Thus an outer tube say of $2\frac{1}{2}$ inch external diameter, is reduced by this treatment to approximately $1\frac{5}{8}$ inch external diameter.

The concentric electric main so formed can then be again covered on the outside with insulation by any of the methods aforesaid or combination thereof and when covered be again bodily inserted into another tube preferably of iron, which latter tube can be compressed on to the inner tube as aforesaid.

The outer iron tube is then or previously coated with any anti-corrosive mixture, to prevent oxidation.

In addition to the above methods of insulating the rod or tube I arrange in some instances to fill the interior of the inner tubes when jointed and laid with a heavy oil, wax, or other suitable insulating material which may be kept under a heavy head or pressure for the purpose of filling up any flaws in the insulating material and for this purpose holes may be provided in the tubes at convenient distances apart preferably at the junctions where the lengths are connected one with another.

Or I may apply such a head or pressure to the insulation portion of the cable only, with or without suitable insulation containers or receivers.

Or I may keep the entire cable under a head or pressure as above described.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed I declare that what I claim is:—

1. In the manufacture of electric mains composed of comparatively rigid insulated conductors in short lengths coupled one to another covering each length of conductor with several layers of paper, cloth or other fabric by winding on to it sheets of paper &c. of the same length as the rod or tube to be covered or with narrower sheets side by side similarly wound on at right angles to the rod or tube.

2. In the manufacture of electric mains composed of comparatively rigid insulated conductors in short lengths coupled one to another covering each length of conductor by rotating the conductor and causing it to wind on to itself a covering of paper or fabric whilst it is lying in a V trough or similarly supported and pressed upon by a roller or otherwise.

3. In the manufacture of electric mains composed of comparatively rigid insulated conductors in short lengths coupled one to another covering each length of conductor with insulating material by simultaneously winding on to it spirally two or more narrow paper strips set side by side substantially as described.

4. In the manufacture of electric mains composed of comparatively rigid insulated conductors in short lengths coupled one to another covering each length of the conductor with insulating material by simultaneously winding on to it two or

more layers of narrow strips of paper or fabric with the edges of the several strips in one layer breaking joint with or intermediate of the edges of the strips in the next layer.

5. In the manufacture of electric mains composed of comparatively rigid insulated conductors in short lengths coupled one to another covering each length of conductor with paper or fabric wound around it and with the edges of the fabric at the two ends of the insulating covering winding around the conductor in a slow spiral substantially as described.

6. An electric main composed of comparatively rigid insulated conductors in short lengths coupled one to another with the insulation on each length coned at each end so as to overlap at the joints substantially as described.

7. In the manufacture of electric mains consisting of comparatively rigid concentric tubular conductors in short lengths coupled one to another first covering a length of the inner conductor with paper a fabric saturated with insulating material by rotating the conductor and causing it to wind the paper or fabric on to itself—then placing the coated conductor within a length of the outer tubular conductor and causing this outer tube to be closed tightly on to the insulating material which surrounds the inner conductor and afterwards covering the outer conductor by rotating it and causing it to wind paper or fabric saturated with insulating material on to itself substantially as described.

8. The combination of machinery substantially as described for covering comparatively rigid conductors.

9. Covering comparatively rigid conductors by winding around them paper or fabric previously saturated with paraffin or like insulation.

10. Covering comparatively rigid conductors by winding around them paper or fabric previously saturated with paraffin or like insulation and causing the previously saturated paper or fabric to again pass through liquid insulation as it is being wound on to the conductor.

11. In the manufacture of electric mains composed of short lengths connected end to end of insulated concentric tubular conductors filling the inner conductor with oil or liquid insulating material under heavy pressure and providing holes at intervals through this conductor to allow insulating liquid to pass into the space between the inner and outer conductors and fill up any flaws in the insulating material by which this space is occupied.

12. In the manufacture of electric mains composed of short lengths connected end to end of insulated concentric tubular conductors feeding insulating material to the joints from the inside through the inner conductor substantially as described.

Dated this 31st day of July 1890.

CARPMAEL & Co.,
Agents for the Applicant.

London: Printed for Her Majesty's Stationery Office, by Darling & Son, Ltd.—1890.

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by means of clamps R^I and screws t^{VI}, and to the central conductor of the branch cable K^I is secured a clamp R^{II} by means of a screw W. The clamps R^I and R^{II} carry arms, the upper ends of which have screws S^V and S^{VI} and project up beyond the upper edge of the casing D and serve to establish a connection between the central conductor of the main cable and that of the branch cable by means of a lead strip P^I. When the cables have been connected in the above described manner, the casing is filled up to the upper edge of the middle part D with tar or other insulating liquid of greater specific gravity than water and the cover F is fixed on by means of screws t^{IV}.

The meeting surfaces of the joints of the several parts of the casing are coated with packing material before being fitted together, in order to make fluid tight joints.

In order to prevent any water that may penetrate through the joints of the casing from passing on to the upper surface of the insulating liquid above which the connections are situated, the cover F has a downward projecting rim I all round it, dipping into the insulating liquid and consequently confining the water that leaks into the space between the rim and the edge of the casing.

Figs. 9 and 10 shew an arrangement for connecting a number of branch conducting cables to one or more main cables. In this arrangement the casing consists of a bottom part C, a middle part D and a cover F secured together by screws t^{IV} and t^{IX} as in the previous arrangement, sockets E with packing grooves being formed on the parts C and D for the reception of each cable to be connected. To the bottom part C is fixed a column S carrying two metal pole pieces M and N which are insulated from each other and from the column by means of the plates G of insulating material. The main cables K are connected to each other by copper strips e and the branch cables K^I by means of lead strips P and P^I and the corresponding polar pieces M N, the connection being established in a manner similar to that previously described. These connections are arranged above the surface of the insulating liquid with which the casing is filled up to the upper edge of the part D, and which consequently covers all the cable ends.

Dated this 2nd day of September 1887.

ABEL & IMRAY,
Agents for the Applicant.

FIG. 3.

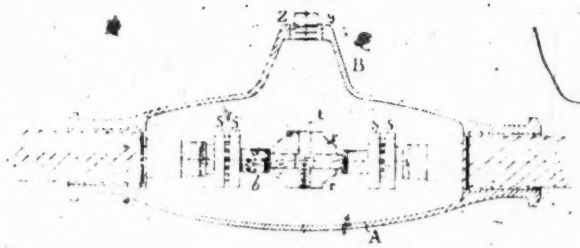


FIG. 4.

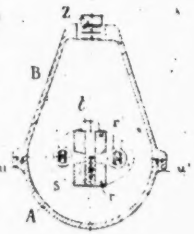


FIG. 7.

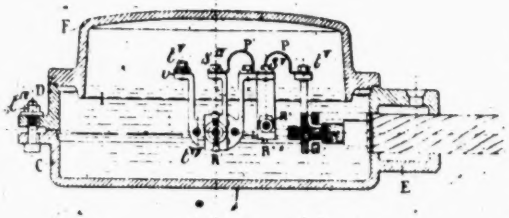


FIG. 5.

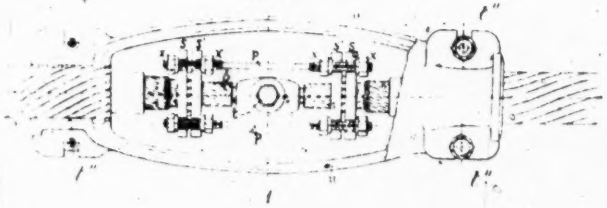


FIG. 6.

FIG. 8.

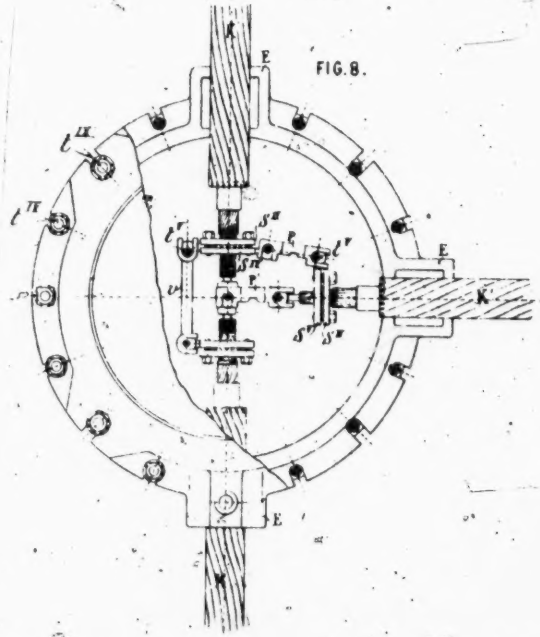
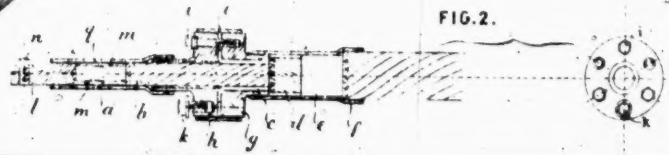


FIG. 1.

FIG. 2.



This Drawing is a reproduction of the Original on a reduced scale.

A.D. 1887. Sep. 2. N° 11,932.

3337 ABEL'S Provisional Specification.

FIG. 9.

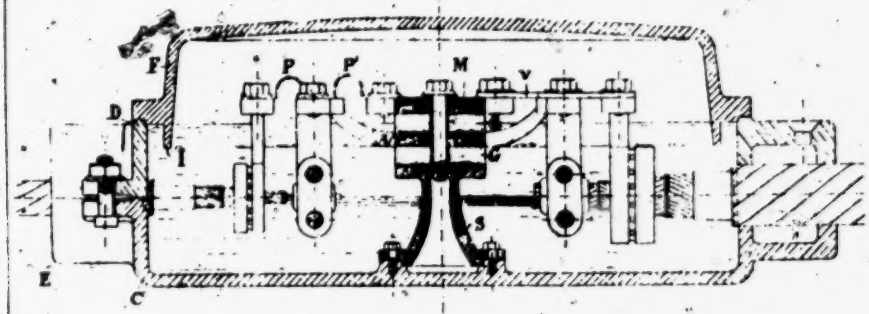
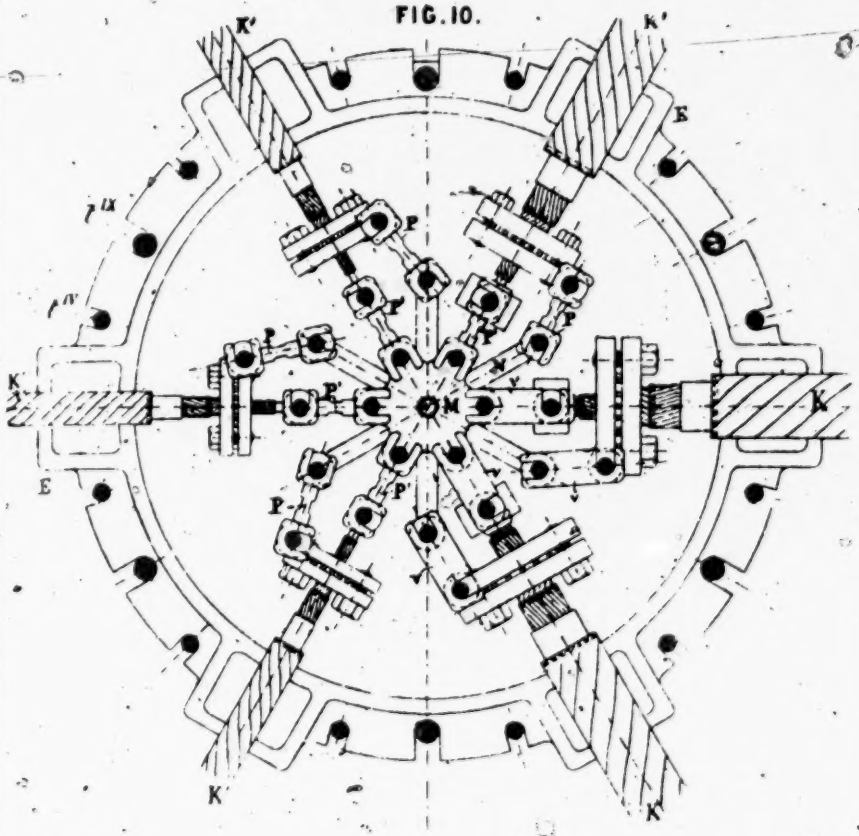


FIG. 10.



[This Drawing is a reproduction of the Original on a reduced scale.]

Malby & Sons, Photo-Litho.

N° 16,237 A.D. 1889

Date of Application, 15th Oct., 1889
Complete Specification Left, 1st Aug., 1890—Accepted, 15th Oct., 1890

PROVISIONAL SPECIFICATION.

Improvements in Electrical Mains and in their Manufacture.

I, SEBASTIAN ZIANI DE FERRANTI, of 120 Fellows Road, Hampstead, in the County of Middlesex, Electrician, do hereby declare the nature of this invention to be as follows:—

My improvements relate to the insulation of electrical conductors which are made in short lengths of comparatively rigid rods or tubes coupled together end to end by suitable couplings.

In order to insulate the several lengths of the rods or tubes I wind around each length a sheet or sheets of paper soaked in an insulating material say for example melted paraffin and this I do by rotating the rod or tube and causing it to wind the paper around itself. I use sheets of paper each of a length equal to the length of the rod or tube to be covered and of any convenient width so that when wound on to the rod or tube the several layers of paper may be complete in themselves and uniform insulation be obtained throughout the length of the rod or tube.

To wind on the paper I preferably place the rod or tube in a V or other conveniently shaped groove or trough capable of holding, or of being submerged in, an insulating material, liquid or liquid when hot and I cause one or more weights such as rollers to bear upon the tube or rod at or near its top and along the whole or a portion of its length. A sheet of paper is laid on to a table at one side of the trough or groove and one edge of it which is of a length equal to the length of the rod or tube to be covered is led below the rod or tube and between it and the trough or groove and then upwards and between it and the weights of roller. The liquid insulation is then made to more or less fill the trough or groove and the rod or tube is turned in such a direction as to wind on the paper.

In some cases it is desirable to stick or fasten the first sheet of paper to the rod or tube before placing it in the liquid insulation.

This I do by the use of shellac, shellac varnish or any suitable gum or adhesive mixture.

When one sheet has so been nearly wound on, the edge of a new sheet may be laid over the portion of the first sheet which still remains unwound and as the rod or tube is continued to be rotated be carried onwards by the first sheet into the trough and around the rod or tube.

In some cases I employ hand pressure, one or more weights, (such as rollers) or springs, or any such suitable device to press the two sheets of paper closer together, and thus increase their cohesion.

Another method is to lay the edge of the new sheet of paper over a portion of the partially wound sheet of paper and cause one or more heavy weights (such as rollers) of suitable section to run along a portion, or the whole of the entire length of the overlapping paper, and thus press or corrugate one sheet of paper into the other.

Or I may attach the new sheet of paper to the partially wound one by means of shellac, shellac varnish, or other suitable gum wax or adhesive mixture, applied along the whole or a portion of the edge of one or both sheets of paper, or otherwise as may be most convenient.

Another method is to wind simultaneously onto the rod or tube 2 or more sheets of paper so arranged that the edge of one sheet is always slightly in advance of the edge of the other sheet of paper.

The edges of the 2 or more new sheets of paper to be wound on, are entered and dovetailed between the 2 or more sheets of paper partially wound on, and if required additional adhesion between the several sheets may be given by any of the previously enumerated methods.

In place of each sheet of paper being of the same length as the rod or tube two or

Fig 1.

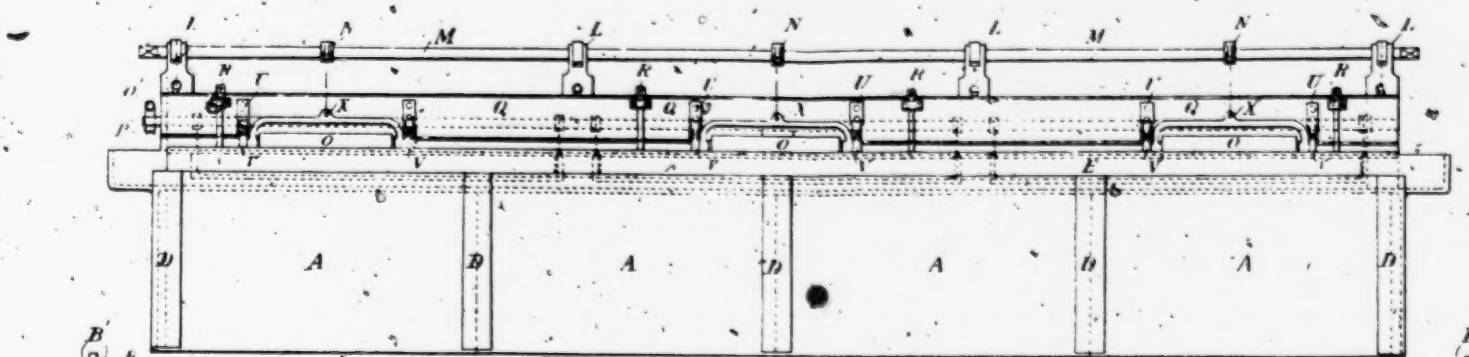
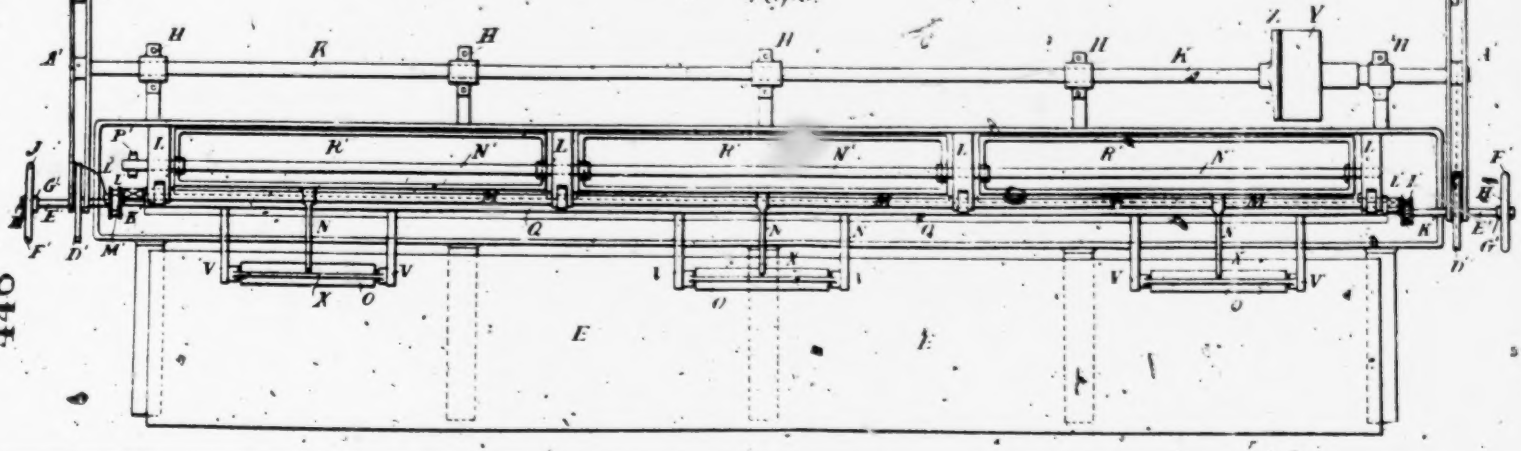


Fig 3.



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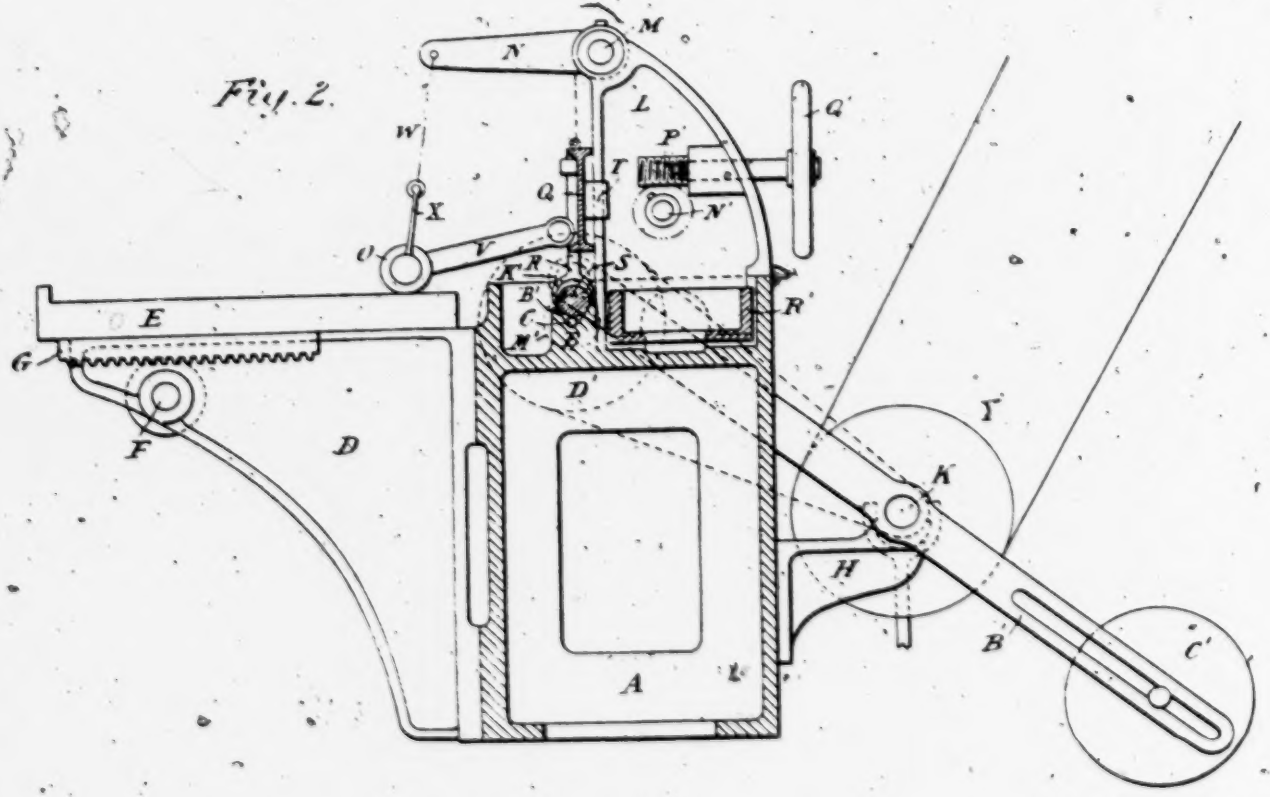
This Drawing is a reproduction of the Original on a reduced scale

Fig. 2.



447,346

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SHEET 3

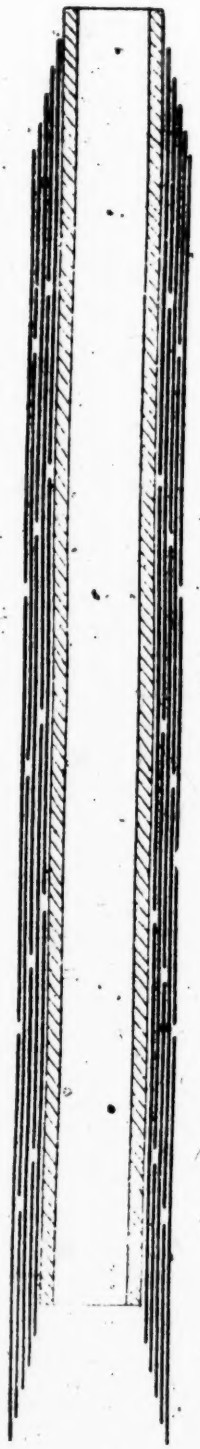

Fig. 5.

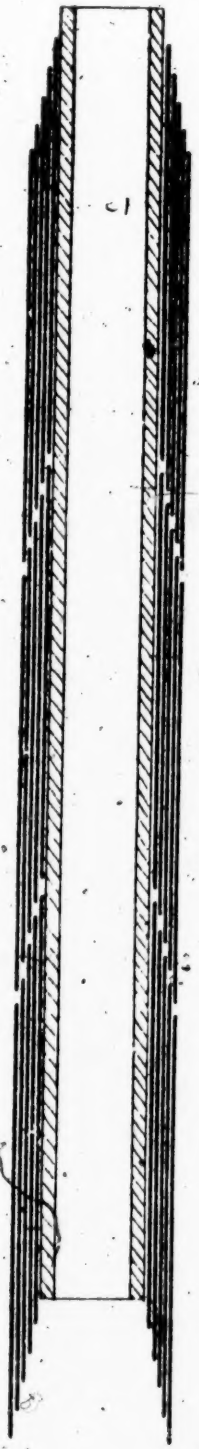

Fig. 4.

PLAINTIFF'S EXHIBIT No. 7 F

450

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(No Model.)

B. H. WESSLAU & G. TRAUTWEIN.

JOINT FOR COUPLING UNDERGROUND CABLES.

No. 415,751. Patented Nov. 26, 1889.

Fig. 1.

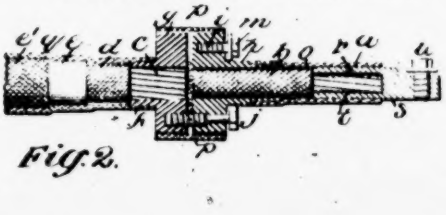


Fig. 2.

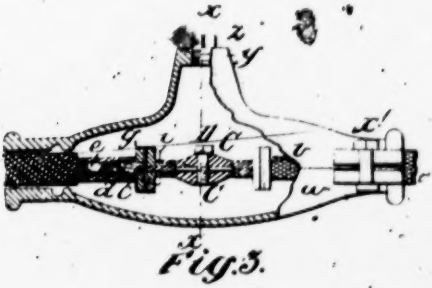


Fig. 3.

Fig. 5.

Fig. 4.

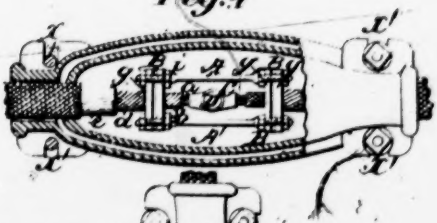


Fig. 6.

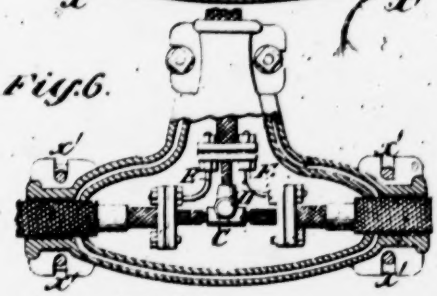
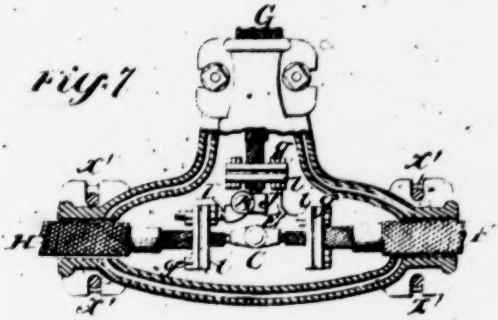


Fig. 7.



WITNESSES

Fred. Kelly

Jesse W. Murray

INVENTORS

By Hermann Wesslau

Georg Trautwein

By C. S. Whitman Attorney

UNITED STATES PATENT OFFICE.

BROR HEMMING WESSLAU AND GEORG TRAUTWEIN, OF CHARLOTTENBURG, PRUSSIA, ASSIGNORS TO SIEMENS & HALSKE, OF BERLIN, GERMANY.

JOINT FOR COUPLING UNDERGROUND CABLES.

SPECIFICATION forming part of Letters Patent No. 415,751, dated November 26, 1889.

Application filed February 4, 1887. Serial No. 226,568. (No model.) Patented in Germany April 27, 1887, No. 42,256 and No. 43,673; in England September 2, 1887, No. 11,932; in France December 20, 1887, No. 187,711, and in Austria-Hungary February 18, 1888, No. 44,641 and No. 5,213.

To all whom it may concern:

Be it known that we, BROR HEMMING WESSLAU and GEORG TRAUTWEIN, both of Charlottenburg, in the German Empire, have invented certain new and useful Improvements in Joints for Coupling Underground Cables, (which have been patented in the German Empire by Letters Patent No. 42,256 and No. 43,673, of April 27, 1887; in England by Letters Patent No. 11,932, of September 2, 1887; in France by Letters Patent No. 187,711, of December 20, 1887, and in Austria-Hungary by Letters Patent No. 44,641, Tom. 38, Fol. 351, and No. 5,213, Tom. XXII, Fol. 325, of February 18, 1888,) of which the following is a specification.

Our invention relates to means for coupling underground electrical cables having a central conductor and another conductor concentric thereto; and it consists in apparatus for joining the said conductors and for protecting the joint formed thereby, and in the combination and arrangement of the parts thereof, as will be hereinafter fully described, and pointed out in detail in the claims.

Couplings for underground cables have to fulfill two principal requirements. In the first place they must be safe mechanically and electrically, and, secondly, they must be so constructed as to prevent the permeation of moisture into the insulating-layers thereof. We obtain these objects by the use of the apparatus shown in the accompanying drawings, and in which corresponding parts are designated by similar letters.

Referring thereto, Figure 1 is a side view, partially sectional, of an end closure for a cable having its central conductor formed of a single wire and constructed according to our invention. Fig. 2 is a side view, partially sectional, of an end closure adapted for use with a cable, the central conductor of which consists of a number of wires twisted into a strand. Fig. 3 is a side view, partially sectional, of a coupling for connecting two cables, showing the side of the protective casing broken away. Fig. 4 is a top view of Fig. 3. Fig. 5 is a vertical section on line $x\,x$ of Fig. 3. Fig. 6 is a top view, having a part of the protective casing broken away, of apparatus used for connecting three cables meeting at a certain point. Fig. 7 is a top plan view, having the protective casing broken away, of apparatus used for connecting a branch cable in series with a throughgoing cable.

In order to connect a cable constructed in the manner described with other conductors, the several layers of the cable are cut off into steps, so that a part of the central conductor *a*, part of the insulating-layer *b* surrounding it, part of the concentric conductor *c* surrounding the said layer, part of the insulating *d* about the conductor *c*, and part of the lead covering *e*, surrounded by a wire covering *e'*, will be exposed. Upon the exposed end of the concentric conductor *c* is shoved a tube *f*, having a flange *g* on the rear end thereof. Upon the insulating-layer *b* is shoved a tube *h*, having a flange *i* upon the forward end thereof. Between the two flanges *g* and *i* the wires of the concentric conductor *c* are turned outward and held securely therebetween by means of the screws *j*, working in threaded holes in the flanges. The flange *i* receives another threaded hole for the reception of a screw *m*, by which a conductor may be attached, and thus an electrically and mechanically safe connection formed with the said concentric conductor. Upon the cable end thus prepared three bands *o*, *p*, and *q* of insulating-tape are wound. The first band *o* surrounds a part of the central conductor, part of the insulating-layer *b*, and part of the tube *h*. The second band *p* surrounds the flanges *g* and *i*, while the third band *q* surrounds the tube *f*, part of the insulating-layer *d*, lead covering *e*, and part of the wire covering *e'*, thus preventing moisture from permeating the interior of the cable and destroying its insulation. It is evident that the conductor *a* may be connected to other conductors in the usual and known manner.

Fig. 2 illustrates an end closure for use with cables having a central conductor composed of a number of wires twisted up into a strand. In this case a metal tube *r*, terminating in a flat end piece *s* and having a female screw-thread *t* upon its interior, is screwed upon such central conductor. The

resin and insuline oil hereinbefore described, an insulating compound of any desired degree of plasticity or fluidity may be produced without materially effecting the high insulating capacity of either of the constituents. For example, should it be found desirable to produce an insulating medium to saturate the paper sheathing for an electrical cable, the oil and the resin would be mixed in such proportions that the resultant compound would flow freely enough to thoroughly impregnate the paper. On the other hand should the compound be intended for use in connection with a textile or fibrous wrapping or sheathing of the cable, it is obvious that the compound should preferably possess somewhat high viscosity, and to effect this result a larger proportion of the resin would be employed. In any event the oil and resin may be freely combined in proportions best suited to the particular conditions under which the insulating material is to be applied and employed.

While the compound consisting of the insuline oil and insuline resin, hereinbefore described, is in itself admirably adapted to most purposes in the electrical arts, it will be understood that the compound aforesaid may be used with any of the well known insulating media, such for example, as rosin, rosin oil, paraffin, and paraffin oils.

The compound alone or in admixture with other insulating media may be applied to the insulating sheath of cables and the like by any improved method, either as a mass filling between the exterior sheath and the cable proper, or as an impregnating medium for the windings or wrappings for the cable.

What I claim is:

An insulating compound comprising a resin derivative in the form of a soft, non-drying, non-oxidizing permanently plastic mass, and a resin oil in the form of a non-oxidizing, non-drying, non-saponifiable resin derivative.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

DORRIS WHIPPLE.

Witnesses:

MERLE I. ST. JOHN,

HARRIETT E. REESE.

Second Edition.

N° 29,756 A.D. 1913

Date of Application, No. 29,756, 24th Dec., 1913
" " No. 1850, 23rd Jan., 1914
" " No. 8828, 7th Apr., 1914
Complete Specification Left, 21st Apr., 1914
(Section 16 of the Patents and Designs Act, 1907.)
Complete Specification Accepted, 25th Jan., 1915

(Sealed April 24/1915)

PROVISIONAL SPECIFICATION.

No. 29,756, A.D. 1913.

Improvements in Electric Cables.

We, JOHN FRANCIS WATSON, Engineer, of "The Lodge," Westcombe Park Road, Blackheath, S.E., and CALLENDER'S CABLE & CONSTRUCTION COMPANY LIMITED, Engineers, of Hamilton House, Victoria Embankment, in the City of London, do hereby declare the nature of this invention to be as follows:—

According to this invention the conductor is surrounded by liquid (such as oil) under pressure. Usually this is done by forcing liquid into the interstices between the insulated conductors and the watertight sheath.

Dated this 24th day of December, 1913.

JOHN FRANCIS WATSON.
CALLENDER'S CABLE & CONSTRUCTION COMPANY LIMITED.

The common seal of Callender's Cable and Construction Company, Limited, was affixed hereto in the presence of

J. FORTESCUE FLANNERY,
CHAS. H. McEWEN,
Directors.
WALTER ALLNUTT,
Secretary.

PROVISIONAL SPECIFICATION.

No. 1850, A.D. 1914.

Improvements in Electric Cables.

We, JOHN FRANCIS WATSON, Engineer, of "The Lodge," Westcombe Park Road, Blackheath, S.E., and CALLENDER'S CABLE & CONSTRUCTION COMPANY LIMITED, Engineers, of Hamilton House, Victoria Embankment, London, E.C., do hereby declare the nature of this invention to be as follows:—

In a system of electric cables for power or light distribution purposes which are insulated with paper or other dielectric impregnated with oil or other

insulating material, it is found that an increase of the dielectric strength and a reduction in the dielectric loss of the insulation can be obtained by filling all interstices of the conductor and dielectric of the cable with oil or other suitable insulating material by the application of pressure in excess of the normal barometric pressure.

In our invention we propose to attach to such cables apparatus capable of applying insulating material at the extra pressure required for the purpose of filling the interstices of the strand and dielectric of the cables, and operating the cables whilst under this pressure.

This process may be continuous or intermittent as required.

Dated the 23rd day of January, 1914.

JOHN FRANCIS WATSON.
CALLENDER'S CABLE & CONSTRUCTION COMPANY, LIMITED.

The common seal of Callender's Cable and Construction Company, Limited, was affixed hereto in the presence of

JOHN VARLEY,
CHAS. H. McEWEN,
Directors.
WALTER ALLNUTT,
Secretary.

PROVISIONAL SPECIFICATION
No. 8828, A.D. 1914.

Improvements in or relating to Electric Cables.

We, JOHN FRANCIS WATSON, Engineer, of "The Lodge," Westcombe Park Road, Blackheath, S.E., and CALLENDER'S CABLE & CONSTRUCTION COMPANY LIMITED, Engineers, of Hamilton House, Victoria Embankment, London, E.C., do hereby declare the nature of this invention to be as follows:—

This invention has reference to electric cables of the kind used for the supply of electric energy for lighting, motive power and other purposes wherein one or more electric conductors is or are insulated with layers of paper, fibre or other insulating material (hereinafter referred to as insulating material) and enclosed in a sheath or cover of flexible metal, such as lead to form a flexible cable. In such cables the interstices that ordinarily exist therein between the metal conductor or each conductor and the insulating material, between the layers of insulating material, or between the wires of which the conductor or each conductor is formed, or between some or all of these portions of the cable, even when the insulating material has been impregnated, as usual, with oil or other insulating material before the flexible metal sheath is applied thereto, reduce the dielectric strength of the insulating material with consequent increase of the dielectric loss when the cable is in use, which effect becomes serious, when the cable carries an alternating current at extra high voltage.

In order to increase the dielectric strength and reduce the dielectric loss of the insulating material used in a flexible cable of the kind referred to whilst the cable is in use and thereby to enable the cable to be safely worked at a greater voltage per unit thickness of dielectric than heretofore usual and to enable the current carrying capacity of each unit section of the copper in the

conductor or each conductor to be increased, whilst at the same time increasing the life of the cable, there is described in the Specifications of other Applications for Letters Patent filed by us, *viz.* Nos. 29,756 of 1913 and 1850 of 1914, a construction of flexible electric cable of the kind referred to wherein the interstices therein, which are ordinarily under vacuum or full of air, are filled with oil or other suitable insulating material. For this purpose the oil or other insulating material may be forced into one end of the flexible cable by a pressure pump whilst the other end is being exhausted, as for example by a vacuum pump, the forcing of oil or other insulating material into the cable under pressure being effected continuously or intermittently, as described in the Specifications of other Applications for Letters Patent Nos. 29,757 of 1913 and 1851 of 1914 filed by us.

Now according to the present invention in order to facilitate the easy and rapid removal of air from the interstices in the cable and the filling of such interstices with oil, for example mineral oil such as used for cylinder lubricating purposes, or with other suitable liquid or liquefiable insulating material (all hereinafter included in the term oil), the cable is so constructed as to possess greater porosity in the direction of its length than heretofore usual by the formation therein of longitudinally extending ducts or passages. Such ducts or passages can be formed in various ways and in different parts of the cable as seen in cross section. Thus, they may be formed by one or more lengths of insulating material arranged between the wire strands forming the conductor or each conductor and the surrounding insulating material, or between separated and concentric rings or layers of the insulating material, or between each of such parts. Such lengths of insulating material may be in the form of separate lengths of twine or the like wound around the conductor with a long or quick pitch and in an opposite direction to the lay of the wires forming such conductor and around one or more rings or layers of the insulating material in the operation of insulating the conductor. Or one or more long strips of corrugated and, it may, be perforated sheet insulating material may be arranged in the form of a ring or rings between concentric portions of the insulating material in the cable. Or lengths of both forms of insulating material may be used in different parts of the cable as seen in a cross section thereof. Or the greater porosity in the direction of the length of cable may be produced by winding the layers of paper, fibre or the like used for insulating the conductor or conductors less tightly upon the conductor or conductors than usual.

A cable constructed to possess greater porosity in the longitudinal direction than usual, as described, is, after being sheathed with flexible metal, as lead, with or without previous impregnation of the paper or other insulating material therein, which in either case is previously dried as usual, treated as described in the said former specifications to remove air from the interstices therein and fill the same with oil under pressure. To facilitate the flow of the oil into place the cable may in some cases be heated externally or, it may be, internally by electric current.

Cables constructed as described can be laid in the usual way, the several lengths thereof being jointed together and all moisture and air removed from the joint boxes and from the interstices at the ends of the cable, preferably by the method now well known as the vacuum and pressure jointing method, the joint boxes, after removal of air therefrom, being filled with oil or other liquid or semi-liquid insulating material herein referred to as oil. This method ensures that the cable made as described is, when laid, effectually filled with oil throughout its length including the joint boxes. The terminal boxes are or may be similarly filled with oil.

In order to prevent the oil in the cable being electrically disrupted or forced out of the interstices, or interstices and ducts or passages, therein by electrostatic action when the cable is in use, particularly when it is heavily loaded, and thus to maintain the increased dielectric strength and reduced dielectric

loss of the insulation obtained as described unimpaired, the oil in the cable and joint and terminal boxes is subjected to a pressure in excess of the normal barometric pressure and such pressure maintained whilst the cable is in use. Such pressure may be applied artificially by means of a pressure pump or equivalent means, connected for example to a branch pipe on each box and the pressure afterwards maintained, as by a weighted plunger, at a suitable predetermined value, say of the order of about forty to eighty pounds per square inch above ordinary atmospheric pressure. Or each box after it has been exhausted of air and refilled with oil may be closed and sealed so that the desired pressure can be set up by the expansion of the oil, the paper or other insulating material and the copper conductor or conductors caused by the heat generated in the latter conductor by the current flowing therethrough when the cable is under load. When thus operating, the pressure will vary automatically with variation in the heat generated in the conductor or conductors by varying current. To provide for the varying amounts of expansion of the materials used and prevent undue hydrostatic pressure being thereby set up within the cable, the joint and terminal boxes, or some of them, may be provided with an air chamber containing air under pressure which will allow for expansion and contraction of the materials comprising the cable and enable a pressure to be continuously maintained on the oil in the cable that will vary automatically with varying load on the cable. The air chamber may be placed out of communication with the interior of the box with which it is used, when exhausting air from such box and adjacent end portions of the cable and replacing such air with oil, after which the communication is reopened between the air chamber and box and air forced into the former by a pump until a suitable pressure is obtained, say, for example, a pressure of about forty pounds to the square inch, as indicated for example by a pressure gauge, whereupon the communication between the air pump and air chamber is closed and sealed and the pump removed.

A cable charged with oil as described will work satisfactorily when cold, without subjecting the oil to pressure, but unless the oil is subjected to pressure when the cable is loaded and becomes hot, the whole of the advantages of the invention cannot be obtained.

Dated this 7th day of April, 1914.

For the Applicants,

LLOYD WISE & Co.,

10 New Court, Lincoln's Inn, London, W.C.,

Chartered Patent Agents.

COMPLETE SPECIFICATION.

Improvements in or relating to Electric Cables.

We, JOHN FRANCIS WATSON, Engineer, of "The Lodge," Westcombe Park Road, Blackheath, S.E., and CALLENDER'S CABLE & CONSTRUCTION COMPANY LIMITED, Engineers, of Hamilton House, Victoria Embankment, London, E.C., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention has reference to electric cables of the kind used for the supply of electric energy for lighting, motive power and other purposes and comprising one or more electric conductors insulated with layers of paper, fibre or other insulating material (hereinafter referred to as insulating material) and enclosed

in a sheath or cover of flexible metal, such as lead, to form a flexible cable. In such cables the interstices that ordinarily exist therein between the metal conductor or each conductor and the insulating material, between the layers of insulating material, or between the wires of which the conductor or each conductor is formed, or between some or all of these portions of the cable, even when the insulating material has been dried and afterwards impregnated, as usual, with oil or other insulating material before the flexible metal sheath is applied thereto, increase the dielectric loss when the cable is in use and thereby reduce the effective voltage at which a unit dielectric thickness can be continuously worked efficiently which is a matter that becomes particularly serious when the cable carries an alternating current at extra high voltage.

Now the present invention has for object to reduce the dielectric loss of the insulating material used in a flexible cable of the kind referred to whilst the cable is in use and thereby enable the cable to be safely worked continuously at a greater voltage per unit thickness of dielectric than heretofore usual and to enable the current carrying capacity of each unit section of the copper in the conductor or each conductor to be safely increased whilst at the same time increasing the life of the cable.

For this purpose in a flexible electric cable of the kind referred to constructed according to the present invention, the conductor or each conductor is surrounded or practically surrounded along its entire length by oil in direct contact therewith. For this purpose the interstices between the conductor or each conductor and the lead sheathing and which are ordinarily under vacuum or full of air, are purposely made to extend along the entire conductor as far as is practicable and filled with oil, for example mineral oil such as is used for cylinder and like lubricating purposes, or with other suitable liquid or liquefiable insulating material (all hereinafter included in the term oil) which is forced under pressure into the said interstices. For this purpose the oil may be forced into one end of the flexible cable by a pressure pump whilst the other end is being exhausted, as for example by a vacuum pump, or the exhaustion of air from the cable through one end thereof may be effected first and the forcing of the oil into the other end of the cable effected afterwards, the forcing of oil into the cable under pressure being effected continuously or intermittently, and by means such as described in the Specifications of other Applications for Letters Patent filed by us No. 29,757 of 1913 and No. 1851 of 1914.

In order to more effectually surround the conductor or each conductor with oil interposed between it and its surrounding covering of paper or equivalent insulating material and also to facilitate the easy and rapid removal of air from interstices in the cable and the filling of such interstices with oil, the cable is constructed with one or more longitudinally extending ducts, passages or spaces formed between the conductor or each conductor and the surrounding covering of insulating material by arranging between the conductor or each conductor and its covering one or more lengths of insulating material of such cross section as to form narrow or practically line or point contacts with the conductor and surrounding covering so that as seen in a cross section of the cable, the conductor is supported centrally within and at a distance from the said covering at one point or at a number of points between which and the conductor and covering is a space or a circular row of spaces for the reception of oil. The length or lengths of insulating material thus used may advantageously be in the form of hard twine, as for example whipcord, or the like wound around the conductor with a long or quick pitch and in an opposite direction to the lay of the wires forming such conductor, in the operation of insulating the conductor. The twine, cord or the like is preferably undressed, that is to say, has no size or other like dressing material therein and it need not be impregnated with oil or other insulating material before being wound on the conductor. Conveniently a number of such lengths of hard twine or cord may be used, spaced apart and wound around the conductor so as to form a number of helical passages extending longitudinally of the cable and of small radial

thickness, say of the order of about 0.05 to 0.1 of an inch. Or one or more long strips of corrugated and, it may be, perforated sheet insulating material may be arranged in the form of a ring between the conductor or each conductor and its covering of insulating material so as to touch these parts at a number of points around them and form a number of straight longitudinal passages between the parts mentioned.

In the accompanying illustrative drawings, Figs. 1, 2, 3 and 4 show in cross section, different constructions of flexible cable having ducts or passages formed therein as hereinbefore described and Fig. 5 shows, in side elevation, lengths or sections of cable connected up for use according to the invention.

Fig. 1 represents a single core cable and shows how separated lengths of twine *a* can be wound helically and openly around the central conductor *b* and the concentric layers of paper or like insulating material *c* wound over the lengths of twine *a* to form longitudinally extending helical ducts or passages *d* in the cable as and for the purpose hereinbefore explained, *e* being the enclosing lead sheath. When the conductor is a stranded one, as shown in this figure, the lengths of twine *a* practically touch the conductor *b* at points and the paper or like insulating covering *c* along lines of contact and form with these parts as seen in a cross section of the cable, an annular row of ducts or passages *d* for the reception of oil that practically surround the conductor and being of greater dielectric strength than the paper or like material forming the insulating covering *c*, will very considerably reduce the dielectric loss that takes place in the cable when the latter is in use, as compared with cables in which the paper or like insulation is wrapped directly and closely upon and around the conductor. Also, when the conductor is a stranded one, the ducts or passages *d* will be in free communication with each other and form practically a single space surrounding the conductor.

Fig. 2 represents a three core cable each of the stranded wire conductors *b* of which is wound with lengths of twine *a* over which the paper or like insulating material *c* is wound as in the single core cable shown in Fig. 1.

Fig. 3 shows a concentric cable wherein the inner stranded wire conductor *b* has lengths of twine *a* wound around it, as in the other examples shown, over which is wound the paper or like insulating material *c*, the outer conductor *g*, composed of wires, being wound around the insulating material *c* and provided with an outer covering of insulating material c^1, the whole being enclosed in the lead sheath *e*. In some cases the inner covering of insulating material *c* may be omitted and the outer conductor wound directly around and in an opposite direction to the helically wound length of twine *a*.

When the conductor or each conductor in a cable is of small cross sectional area say under 0.05 square inch, it need not be stranded, that is to say it may consist of a single metal wire around which the length or lengths of twine is or are wound as described.

Fig. 4 is a view similar to Fig. 1 but wherein the lengths of twine *a* are replaced by a length of corrugated and perforated sheet insulating material a^1 as and for the purpose hereinbefore described.

A cable constructed with longitudinally extending ducts or passages as and for the purpose described, is, after being sheathed with flexible metal as lead, with or without previous impregnation of the paper or other insulating material therein, which however in either case is previously dried as usual, treated as hereinbefore described and in the said former specifications, to remove air from the interstices and ducts or passages therein and to completely fill the same with oil under pressure. To facilitate the flow of the oil into place the cable may in some cases be heated externally or, it may be, internally by electric current.

Cables constructed as described can be laid in the usual way, the several lengths or sections thereof being jointed together (see Fig. 5) and all moisture and air removed from the joint boxes *f* and from the interstices and ducts or passages at the adjacent end portions of the cable, preferably by the method now well

known as the vacuum and pressure jointing method, the joint boxes *f*, after removal of air therefrom, being filled with oil or other liquid or semi-liquid insulating material herein referred to as oil. This method ensures that the cable made as described is, when laid, effectually filled with oil throughout its length including the joint boxes. The terminal boxes are or may be similarly filled with oil.

In order to prevent the oil in the cable being electrically disrupted or forced out of the interstices, or interstices and ducts or passages *d* therein by electrostatic action, when the cable is in use, particularly when it is heavily loaded, and thus to maintain the increased dielectric strength and reduced dielectric loss of the insulation obtained as described unimpaired, the oil in the cable and joint and terminal boxes is subjected to a pressure in excess of the normal barometric pressure and such pressure maintained whilst the cable is in use as has been proposed in connection with other constructions of electric cables. Such pressure may conveniently be applied artificially by means of a pressure pump or equivalent means, connected for example to a branch pipe *g* on each box and the pressure afterwards maintained as by a weighted yielding plunger *h*, at a suitable predetermined value, say of the order of about forty to eighty pounds per square inch above ordinary atmospheric pressure. Or each box after it has been exhausted of air and refilled with oil, may be closed and sealed so that the desired pressure can be set up by the expansion of the oil, the paper or other insulating material and the copper conductor or conductors, caused by the heat generated in the latter by the current flowing therethrough when the cable is under load. When thus operating, the pressure will vary automatically with variation in the heat generated in the conductor or conductors by varying current. To provide for the varying amounts of expansion of the materials used and prevent undue hydrostatic pressure being thereby set up within the cable, the joint and terminal boxes, or some of them, may, as shown in Fig. 5, be provided with an air chamber *i* containing air under pressure which will allow for expansion and contraction of the materials comprising the cable and enable a pressure to be continuously maintained on the oil in the cable that will vary automatically with varying load on the cable. The air chamber may be placed out of communication with the interior of the box with which it is used, when exhausting air from such box and adjacent end portions of the cable and replacing such air with oil, after which the communication is reopened between the air chamber and box and air forced into the former by a pump until a suitable pressure is obtained, say, for example a pressure of about forty pounds to the square inch, as indicated for example by a pressure gauge *k*, whereupon the communication between the air pump and air chamber is closed and sealed and the pump removed.

A cable constructed and charged with oil as described will work satisfactorily when cold without subjecting the oil to pressure, but unless the oil is subjected to pressure when the cable is loaded and becomes hot, the whole of the advantages of the invention cannot be obtained.

We are aware that it has been proposed to form, not however in direct contact with conductors, grooves or tunnels in electric cables by interposing between layers of insulating material a number of strands of jute or hemp yarn so arranged that a small space is left between adjacent strands, the object being to enable moisture to be abstracted through the grooves or tunnels which may thereafter be filled with oil. We are also aware that it has been proposed to form spiral ducts or passages in direct contact with a conductor by winding strip insulating material thereon with a narrow space between the convolutions, but in this case the length of the conductor that is exposed to the oil is materially less than that covered by the strip insulating material. No claim is accordingly herein made to such features, nor to the introduction of oil to the grooves or tunnels under a pressure, which is afterwards removed, with the intention of hydraulically testing the cable sheathing; and in a similar way we disclaim as any part of our invention the maintenance of a head to produce pressure upon oil

surrounding conductors laid in tubes that are coupled together to form a pipe cable as distinct from a flexible sheathed cable.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A flexible sheathed electric cable of the kind herein referred to wherein the conductor or each conductor is surrounded or practically surrounded along its entire length by a layer or layers of oil in direct contact therewith, substantially as described.

2. A flexible sheathed electric cable of the kind herein referred to wherein the conductor or each conductor is surrounded or practically surrounded along its length by a layer or layers of oil interposed directly between it and the layers of paper or like insulating material covering such conductor, substantially as described.

3. A flexible sheathed electric cable of the kind herein referred to having therein one or more longitudinally extending oil filled ducts or passages located between the conductor or each conductor and its covering of paper or like insulating material and formed by one or more longitudinally extending lengths of insulating material of such cross section as to bear against the conductor at one or more points or parts of its circumference as seen in any cross section of the cable, substantially as described.

4. A flexible sheathed electric cable according to the preceding claim wherein the longitudinally extending duct or passage or ducts or passages is or are formed by one or more lengths of twine, or equivalent, of small cross section and wound around the conductor in the form of an open helix or coil or helices or coils, substantially as described.

5. The combination with a flexible sheathed cable according to any of the preceding claims of means whereby the oil in the cable can be subjected to a yielding pressure greater than the normal barometric pressure whilst the cable is in use.

6. The combination with an electric cable according to Claims 1, 2, 3 or 4 of one or more boxes which or each of which is in communication with the interior of the cable, is charged with oil or other liquid or semi-liquid insulating material and provided with means, such as a weighted plunger, whereby a yielding pressure greater than the normal barometric pressure can be imparted through the oil or other liquid or semi-liquid insulating material in the box to the oil in the cable and the pressure maintained whilst the cable is in use, substantially as described.

7. The combination with an electric cable according to Claims 1, 2, 3 or 4 of one or more sealed boxes which or each of which is in communication with the interior of the cable, is charged with oil or other liquid or semi-liquid insulating material and provided with an air chamber charged with air under a pressure greater than the normal barometric pressure so that the pressure continuously maintained on the oil in the cable will vary automatically with varying load on the cable, substantially as described.

8. Flexible electric cables of the kind herein referred to constructed substantially as hereinbefore described with reference to the examples shown in the accompanying drawings.

Dated this 21st day of April, 1914.

For the Applicants,
LLOYDWISE & Co.,
10, New Court, Lincoln's Inn, London, W.C.,
Chartered Patent Agents.

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[Wt. 21a—50/7/1925.]

Fig 1

Fig 2

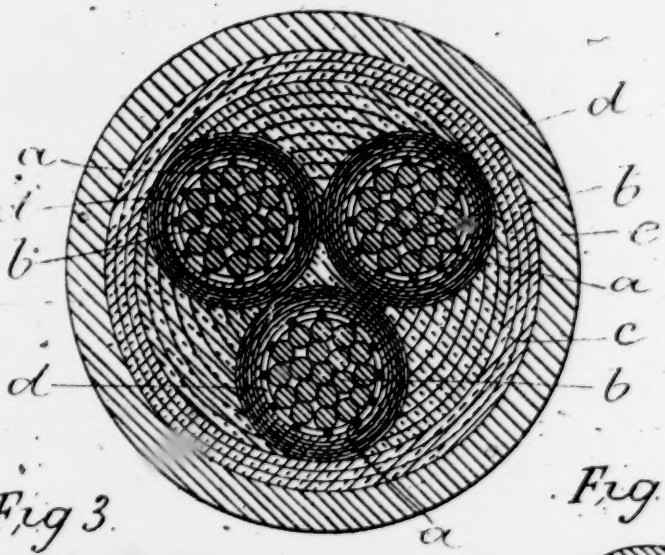


Fig 3

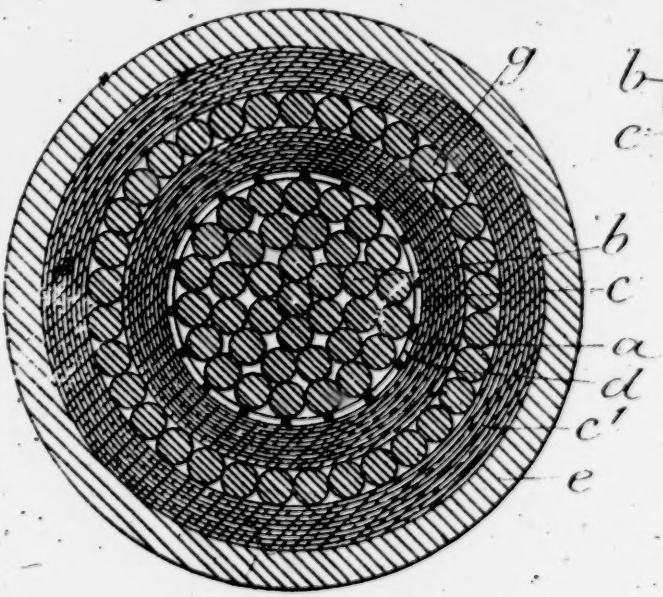
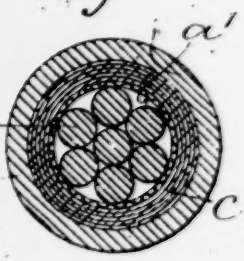


Fig 4



[This Drawing is a reproduction of the Original on a reduced scale]

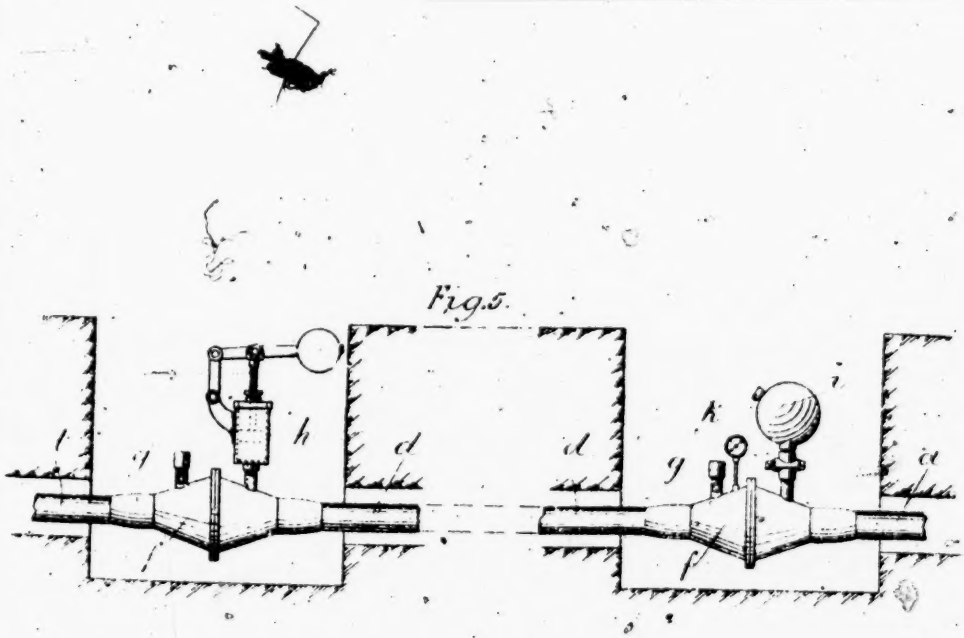


Fig. 5.

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PLAINTIFF'S EXHIBIT NO. 7 A

N° 8842 A.D. 1914

Date of Application, 7th Apr., 1914

Complete Specification Left, 6th Oct., 1914—Accepted, 29th Apr., 1915

PROVISIONAL SPECIFICATION.

Improvements in or relating to Electric Cables.

We, WILLIAM FREDERICK PRICE, Engineer, of Hutton, Freta Road, Bexley Heath, in the County of Kent, and CALLENDER'S CABLE & CONSTRUCTION COMPANY LIMITED, Engineers, of Hamilton House, Victoria Embankment, London, E.C., do hereby declare the nature of this invention to be as follows:—

This invention has reference to electric cables of the kind used for the distribution of electric energy for lighting, motive power and other purposes wherein oil or other liquid or liquefiable insulating material is used in conjunction with paper, fibre or other solid insulating material for insulating the conductor or conductors. When a long cable of this kind is laid in or over uneven ground, for instance up the side of a hill or mountain, the cable is subject to internal hydraulic pressure at different points of its length, such pressure varying with the difference in level at those points and being due to the head of liquid or semi-liquid insulating material in the cable. Such pressure may in extreme cases be sufficient to burst the sheathing of the cable even if this be reinforced by armouring.

Now this invention has for object to prevent excessive internal hydraulic pressures being set up in a long cable of the kind referred to under the circumstances mentioned.

For this purpose sections of the cable that are laid at considerable differences in level are connected together by interposed pressure limiting boxes constructed to completely separate the insulating material and lead or other metal sheathing of adjoining sections and the interiors of such sections from each other whilst allowing of the conductors of the adjacent sections being connected together to maintain the continuity of the conductor or conductors. In this way the hydraulic pressure set up in the different portions of cable that are inclined to the horizontal or are vertical can be limited to a safe value.

Pressure limiting boxes as and for the purpose set forth can be constructed in various ways.

Conveniently each of such boxes may comprise two end portions of truncated conical or equivalent shape adapted to be secured in a fluid tight manner to the lead or other sheathing on the adjacent sections of cable and an intermediate plate or division to which the larger ends of the two end portions of the box can be secured, as by bolts and nuts, the intermediate plate or division carrying one or more short lengths of insulated conductors that extends or extend in a fluid tight manner through the intermediate plate or division and to the ends of which the ends of the conductors in the adjacent sections of cable can be readily connected to maintain the continuity of the conductor or each conductor through the box. The short length of conductor or each such length of conductor may advantageously be fixed in a fluid tight manner in and extend through sleeve-like extensions at opposite sides of the intermediate plate or division which may be of metal bushed with suitable insulating material, or of insulating material of sufficient thickness to afford the requisite strength. Each

[Illegible]

end portion of the box is provided with a branch to admit of air being withdrawn therefrom and from the adjacent end of the section of cable and replaced by oil or other liquid or liquefiable insulating material. Also, one or each end portion of the box is or may be provided on its upper side with an air chamber. Such a box can be applied by passing the smaller ends of the two end portions thereof back over the sheathing of the end portions of the sections of cable to be connected, then connecting the bared ends of the lengths of conductor in the sections of cable to the short length or lengths of conductor carried by the intermediate plate or division, then moving the two end portions of the box back and securing their larger ends to the intermediate plate or division and their smaller ends to the sheathing of the adjacent sections of cable in a fluid tight manner, after which the air in the two completely separated portions of the box and the ends of the adjacent sections of cable can be removed by exhausting means and be replaced by oil or other insulating material under pressure, the air chambers, if provided, being charged with air. By the means described the interior of each section of cable is completely separated from those of adjacent sections.

Pressure limiting boxes of the kind hereinbefore described may advantageously be used in connection with sections of cables of the kind described in the Specifications of other Applications for Letters Patent Nos. 29,756 of 1913 and Nos. 1850 and 8828 of 1911, wherein the air in the interstices in the sections or lengths of cable is removed and replaced by oil or other liquid or liquefiable insulating material forced into place under the conjoint influence of suction and pressure.

Dated this 7th day of April, 1911.

For the Applicants,
LLOYD WISE & Co.,
10, New Court, Lincoln's Inn, London, W.C.,
Chartered Patent Agents.

COMPLETE SPECIFICATION.

Improvements in or relating to Electric Cables.

We, WILLIAM FREDERICK PRICE, Engineer, of Hutton, Freta Road, Bexley Heath, in the County of Kent, and CALLENDER'S CABLE & CONSTRUCTION COMPANY, LIMITED, Engineers, of Hamilton House, Victoria Embankment, London, E.C., do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention has reference to flexible electric cables of the kind used for the distribution of electric energy for lighting, motive power and other purposes, wherein oil or other liquid or liquefiable insulating material is used in conjunction with paper, fibre or other solid insulating material for insulating the conductor or conductors. When a long cable of this kind is laid in or over uneven ground, for instance up the side of a hill or mountain, the cable is subject to internal hydraulic pressure at different points of its length, such pressure varying with the difference in level at such points and being due to the head of liquid or semi-liquid insulating material in the cable. Such pressure may in extreme cases be sufficient to burst the flexible sheathing of the cable even if this be reinforced by armouring.

Now this invention has for object to prevent excessive internal hydraulic pressures being set up in a long flexible cable of the kind referred to under the

circumstances mentioned, thereby overcoming the same disadvantages as are avoided in rigid electrical conduits containing liquid for the insulation of bare wire conductors and divided into sections of the length to limit hydrostatic pressure.

For the said purpose of our invention, sections of flexible cable that are laid at considerable differences in level are connected together by interposed pressure limiting boxes constructed to completely separate the insulating material and lead or other flexible metal sheathing of adjoining sections and the interiors of such sections from each other whilst allowing of the conductors of the adjacent sections being connected together to maintain the continuity of the conductor or conductors. In this way the hydraulic pressure set up in the different portions of cable that are inclined to the horizontal, or are vertical, can be limited to a safe value.

Pressure limiting boxes as and for the purpose set forth can be constructed in various ways.

Conveniently each of such boxes may comprise two end portions of truncated conical or equivalent shape adapted to be secured in a fluid tight manner to the lead or other sheathing of the adjacent sections of cable and an intermediate plate or division to which the larger ends of the two end portions of the box can be secured, as by bolts and nuts, the intermediate plate or division carrying one or more short lengths of insulated conductors that extends or extend in a fluid tight manner through the intermediate plate or division and to the ends of which the ends of the conductors in the adjacent sections of cable can be readily connected to maintain the continuity of the conductor or each conductor through the box. The short length of conductor or each such length of conductor may advantageously be fixed in a fluid tight manner in and extend through sleeve-like extensions at opposite sides of the intermediate plate or division which may be of metal bushed with suitable insulating material, or of insulating material of sufficient thickness to afford the requisite strength. Each end portion of the box is provided with a branch to admit of air being withdrawn therefrom and from the adjacent end of the section of cable and replaced by oil or other liquid or liquefiable insulating material. Also, one or each end portion of the box is or may be provided with an air chamber. Such a box can be applied by passing the smaller ends of the two end portions thereof back over the sheathing of the end portions of the sections of cable to be connected, then connecting the bared ends of the lengths of conductor in the sections of cable to the short length or lengths of conductor carried by the intermediate plate or division, then moving the two end portions of the box back and securing their larger ends to the intermediate plate or division and finally securing their smaller ends to the sheathing of the adjacent sections of cable in a fluid tight manner, as for example by plumb joints in the case of lead sheathed cables, after which the air in the two completely separated portions of the box and the ends of the adjacent sections of cable can be removed by exhausting means and be replaced by oil or other insulating material under pressure, the air chambers, if provided, being charged with air. By the means described the interior of each section of cable is completely separated from those of adjacent sections.

In the accompanying drawings, Fig. 1 is a longitudinal section of one arrangement according to the invention, Fig. 2 being a transverse section on the line *x*, *x* of Fig. 1.

As here shown, *a*, *a*^{1} are the separable conical box parts, *b* the division plate to which they are bolted, and *c* the conductors of a three phase cable the insulation of which is shown at *d* and *d*^{1} and the lead sheathing at *e*. *f* are the bushed sleeve-like extensions of the division plate *b* to hold, in a fluid tight manner, the short conductors *g* which are adapted to be connected to the conductors *c*, as for example through pairs of socket pieces *h*, each pair being jointed together at *i* and secured by a pin. Each box part *a* [illegible] provided

a branch *k* with valve for attachment to exhausting means for withdrawing air from the box part and adjacent end portion of the cable and with a branch *m* with valve for attachment to means, such as a pump, for introducing oil or other liquid or liquefiable insulating material into the box part and adjacent end portion of the cable. The box part, for example the box part *a*', that will be at the lower end of an inclined or vertical section of cable when in use, may be provided with an air chamber *n* to compensate for expansion of the material in the section of cable due to increase of temperature. The air in the air chamber may be initially under a pressure greater than atmospheric pressure. Both box parts at the end of a section of cable may, in some cases, be provided with air chambers charged with air under pressure greater than atmospheric pressure in order to maintain the oil or other liquid or liquefiable insulating material under pressure throughout the section.

Pressure limiting boxes of the kind hereinbefore described may advantageously be used in connection with sections of cables of the kind described in the Specifications of other Applications for Letters Patent Nos. 29,756 of 1913 and Nos. 1850 and 8828 of 1914, wherein the air in the interstices in the sections or lengths of cable is removed and replaced by oil or other liquid or liquefiable insulating material forced into place under the influence of suction and pressure.

Having now particularly described and ascertained the nature of the said invention, and in what manner the same is to be performed, we declare that what we claim is:

1. Connecting together the sections of a cable of the kind herein referred to by interposed pressure limiting boxes, substantially as and for the purpose described.

2. A pressure limiting box for the purpose set forth comprising separable parts and an intermediate plate or division having means for carrying a conductor or conductors therethrough in a water tight and insulated manner, substantially as described.

3. A pressure limiting box according to the preceding claim, each portion of which is provided with means whereby air can be withdrawn from it and oil or other liquid or liquefiable material can be fed into it, substantially as described.

4. In a pressure limiting box according to Claim 2, the provision of an air chamber on one or each end box portion, substantially as and for the purpose described.

5. For sections of an electric cable, a pressure limiting box constructed as described and shown.

Dated this 6th day of October, 1914.

For the Applicants,

LLOYD WISE & Co.,

10 New Court, Lincoln's Inn, London, W.C.

Chartered Patent Agents.

Retheil. Printed for His Majesty's Stationery Office by Love & McCormick, Ltd. 1915.

A.D. 1914. April 7. N° 8812
PRICE 4d. Complete Specification.

This Drawing is a reproduction of the Original on a reduced scale.

Fig 1

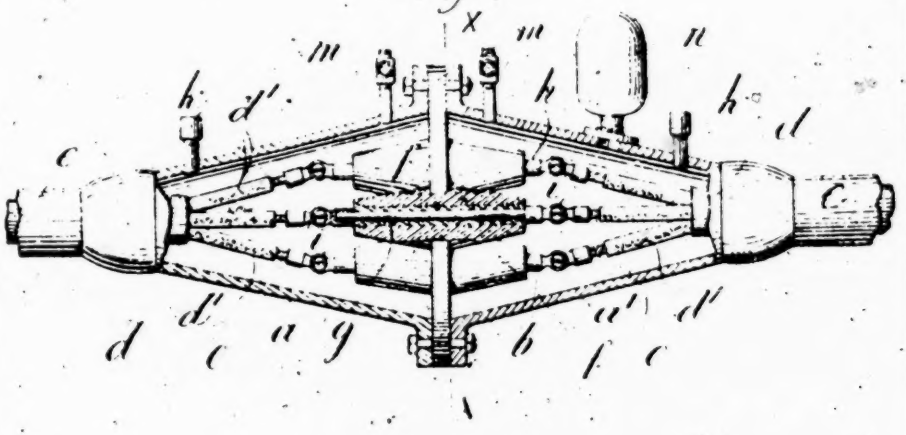
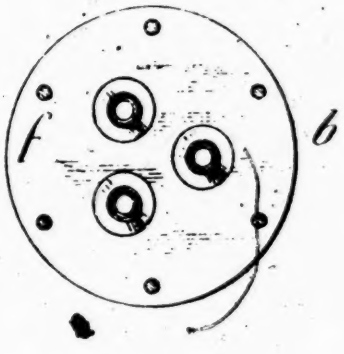


Fig 2



[fol. 471] PLAINTIFF'S EXHIBIT No. 8

UNITED STATES CIRCUIT COURT OF APPEALS, SIXTH CIRCUIT

No. 5132

METROPOLITAN DEVICE CORPORATION, Appellant,

v.

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY, Appellee

Appeal from United States District Court, Northern District of Ohio, Eastern Division

Decided December 6, 1929

Before Denison, Moorman and Hicks, Circuit Judges

HICKS, Circuit Judge:

Suit for infringement of claims Nos. 3 and 4[1] of Torchio Patent No. 1,172,322, granted February 22, 1916, for a Protective Device for Electric Cable Joints. The defenses

[1] "3. An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, inclosing the same and hermetically united at its ends to said cable sheath, and an insulating fluid adapted to permeate said pervious body contained in the space between said body and said sleeve."

"4. An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, inclosing the same and hermetically united at its ends to said cable sheath, a receptacle communicating with the interior of said sleeve, and an insulating fluid adapted to permeate said pervious body contained in said receptacle and the space between said body and said sleeve."

were: (1) lack of invention; (2) anticipation; and (3) non-[fol. 472] infringement. The bill was dismissed for lack of invention. The court disregarded a disclaimer[2] filed four days before the trial. We think it should have been permitted. That portion of the disclaimer disapproved is as follows:

"* * *, and except as to insulating liquid which is fluid at ordinary working temperatures of such cables and in quantity sufficient to supply at all times the demands by the cable in use, and by the joint."

The criticism of the District Judge was, that the limitation sought affected the quality and quantity of the insulating liquid and from his viewpoint the specifications said nothing concerning either. We cannot yield thereto. We think the disclaimer may without violence readily stand upon the following descriptive matter in the specification, to wit:

[fol. 473] "I fill the sleeve and the reservoir with any suitable insulating oil or other liquid which is fluid at low temperature and preferably of a character which will combine with the material used in the body of the cable for permeating or imbedding the insulating wrappings. This liquid I preferably force into the sleeve 8 under pressure sufficient to drive it in the interstices of the cable ends and into the joint wrappings and fillings. When the introduction of the liquid is complete I permit it to fill the reservoir 10 which is finally closed. The oil in the reservoir then

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[2] "No. 1,172,322.—Philip Torchio, New York, N. Y. Protective Device for Electric-Cable Joints. Patent dated February 22, 1916. Disclaimer filed February 11, 1927, by the assignee, Thomas E. Murray.

"Hereby makes disclaimer of the improvement described except for electric cables which comprise a line conductor, insulating wrappings permeated with insulating compound and a sheath of flexible inelastic metal constituting a unitary product of manufacture and commerce which is portable and capable of being drawn through conduits; and except as to an insulating liquid which is fluid at ordinary working temperatures of such cables and in quantity sufficient to supply at all times the demands made by the cable in use, and by the joint."

serves to supply any deficiency in the sleeve caused by absorption and breathing of the cable or the disturbance of the conductors carrying sudden overload currents, so that the joint insulation is not only thoroughly permeated at the outset but continues submerged in a bath of insulating oil."

Again:

"It is to be observed that the insulating fluid not only permeates the wrappings and fillings at the joint but also percolates into the insulation of the cable ends exposed in order to make the joint. This is of practical importance, because it often happens that during the making of the joint, the exposure of said ends permits of the permeating liquid used in the original manufacture of the cable to 'bleed' or run out and a consequent failure of insulation at [fol. 474] these points ensues. This I have found to be the cause of breakdowns which were apparently unaccountable. The new fluid put into the joint sleeve supplies this loss and effectually prevents difficulty."

The specifications fairly set forth the quality of the insulating compound. It is: "fluid at low temperature." Any liquid, fluid at low temperature, is necessarily "fluid at ordinary working temperatures" and the disclaimer therefore sets up no new claim as to quality. The same is true as to the quantity of the liquid and the purpose of its use; to wit: "Quantity sufficient to supply at all times the demands made by the cable in use and by the joint." The specifications fairly call for a quantity sufficient to fill the sleeve and the supplying reservoir so that the joint insulation shall not only be continuously submerged in the oil but that the amount drawn from the sleeve by the absorption and breathing of the cable shall be correspondingly restored to the sleeve from the reservoir.

The record carries no suggestion of any intent to broaden the claims beyond the specification (Tit. 35, Sec. 65, U. S. C.), or any idea of obtaining the benefit of a reissue. We think the effect of the disclaimer is to clear up an awkwardly worded and therefore a somewhat ambiguous description in the specification. See Cambria Steel Co. v. Cambria Iron Co., 185 U. S. 403, 436; Simplex Ry. Appliance Co. v. Pressed Steel Car Co., 189 Fed. 70, 72. We

also think that the disclaimer was not unreasonably delayed. As stated in Sessions v. Romadka, 145 U. S. 229: [fol. 475] "The power to disclaim is a beneficial one and ought not to be denied, except where it is resorted to for a fraudulent and deceptive purpose." In Excelsior Furniture Co. v. Williamson Heater Co., 269 Fed. 614, 619 (C. C. A. 6), disclaimer was allowed after decision on appeal. See also N. O. Nelson Mfg. Co. v. F. E. Meyer & Bro. Co., 29 Fed. (2) 968, 969 (C. C. A. 6). The view we take is, that the matter of disclaimer was within the discretion of the patentee to be reasonably exercised—"a matter of policy"—(Permutit Co. v. Wadham, 13 Fed. [2] 454, 547 (C. C. A. 6), and we think there was sufficient doubt as to whether claims 3 and 4, as originally written, were anticipated to justify the seeming delay. Walker on Patents (2nd ed.), Sec. 255.

As to invention: The necessity therefor was great. In high voltage cables, i. e., cables carrying in excess of 15,000 volts, the dielectric loss from faulty insulation with the resultant destruction of the wrappings of the cable and the breaking down of the joint, was serious. Torchio discovered that this loss was due in part to the "bleeding" of the insulating compound from the exposed cable ends during installation. He also discovered that the cable "breathed" or "sucked," that is that while in use the heat expanded it and that it correspondingly contracted while cooling, that this bleeding and expansion of the cable forced the insulating compound from the interstices of the pervious insulating wrappings and fillings, permitting dielectric loss and structural damage. The problem was to restore this lost insulation. The teaching had been that the insulating compound in the joint should not be soft enough to flow. [fol. 476] The thought was that the compound should not be permitted to escape and leave the joint unprotected. Torchio substituted a liquid insulating compound for the compound with a low melting point theretofore in use in the cable sleeve. Torchio's liquid compound would and did, especially under pressure, flow along the cable length between the conductors and the leaden sheath and refill the empty cells of the pervious insulation. This was new and useful and was a commercial success. It was not a mere refinement of the former method; it was a reversal of it. We think it was somewhat beyond the skill of an expert

and amounted to patentable invention. Gear Grinding Mach. Co. v. Studebaker Corp., 270 Fed. 934, 935 (C. C. A. 6).

Nor was plaintiff's invention anticipated by the prior act. The cable, the insulating compound, the sleeve with its soldered joint, and possibly the cable joint construction, were all old but they were not old in combination. In the new combination they produced a new result and therefore were not anticipated. Webster Loom Co. v. Higgins, 105 U. S. 580, 591; Detroit Carrier & Mfg. Co. v. Dodge Bros., 334 Fed. (2) 745, 747 (C. C. A. 6); Michigan Carton Co. v. Sutherland Co., 29 Fed. (2) 179, 183 (C. C. A. 6); Ferro Concrete Constr. Co. v. Concrete Steel Co., 206 Fed. 666, 669 (C. C. A. 6); Kellogg Switchboard & Supply Co. v. Dean Elec. Co., 182 Fed. 991, 998 (C. C. A. 6).

We have examined the prior art references but review here only those discussed in defendant's brief:

[fol. 477] First: The Brooks-Hunt group,—U. S. patents to Brooks No. 165,535 and No. 210,986, respectively, and the British patent to Hunt No. 4828, communicated from Brooks. These at least approach a non-analogous art. They do not deal with the modern high voltage cable. They are concerned only with low voltage telegraph wires separately insulated and drawn through iron pipes. They were abandoned as useless long before the advent of the unitary cable with the leaden sheath.

Second: British patent No. 11,932 to Abel. This does not involve such a cable as does Torchio. It deals with a cable composed of a central conductor and concentric conductors insulated from each other and with the manner of joining the conductors at the cable ends and when so joined them with joining similar cable ends. The insulating fluid in the sleeve does not contact with the joints. They are protected by impervious caoutchouc.

Third: The British patent to Ferranti, No. 16,237. This discloses a conductor composed of concentric metal tubes. It in no sense deals with joint construction.

Fourth: British patent to Watson, No. 29,756. The District Judge had substantial basis for doubting whether Watson was prior to Torchio. But, independent thereof, it is clear that the Watson patent does not anticipate even if earlier. It discloses a cable in which the conductors are

helically wound in paper wrapped twine, thus forming continuous ducts or channels for the insulating liquid throughout the cable length. It does not disclose joint construc- [fol. 478] tion or joint insulation or teach the method of uniting the joint box or sleeve with the cable.

Infringement. The question of infringement is not difficult. The striking similarity of the devices as illustrated by the drawings and description of defendant's joint as defined in plaintiff's exhibit 7 is conclusive upon the matter of construction. The defense that the viscosity of the insulating compound used in defendant's joint prevents it from oozing or flowing into and through the cable is not persuasive, in view of defendant's admission that this compound, normally of the consistency of vaseline or jelly, did under stress, escape from the reservoirs to the extent of collapsing them, and that for a time it was necessary to periodically refill the joints. Defendant advances no explanation of what had become of the lost compound. There is none, except that the working temperature of the cable heated it and the combined action of the pressure from the reservoir and the "breathing" or "sucking" of the cable during contraction drew it into the cable length. The word "fluid" is not necessarily to be defined with the extreme meaning permitted by the dictionary. Such words are to be given a reasonable interpretation in view of the association. Clipper Belt Lacer Co. v. E-W Co., 237 Fed. 602, 605 (C. C. A. 6); Farrington v. Haywood, decided November 13, 1929.

Finally, upon the above views we conclude that the Torchio patent, No. 1,172,322, was valid and infringed and the decree is therefore reversed with directions to enter a new decree in accordance with this opinion.

[fol. 479] PLAINTIFF'S EXHIBIT No. 9

DISTRICT COURT OF THE UNITED STATES OF AMERICA, NORTHERN DISTRICT OF OHIO, EASTERN DIVISION

At a stated term of the District Court of the United States, within and for the Eastern Division of the Northern District of Ohio, begun and held at the City of Cleveland, in said District, on first Tuesday in April, being the 7th day

of said month, in the year of our Lord one thousand nine hundred thirty, and of the Independence of the United States of America, the one hundred and fifty-fifth, to wit: On Friday, the 12th day of September, A. D. 1930.

Present: Honorable Paul Jones, United States District Judge.

Among the proceedings then and there had were the following, to wit:

No. 1772. Equity.

METROPOLITAN DEVICE CORPORATION

vs.

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

This cause came on for hearing upon the application of the plaintiff for entry of a decree according to the mandate of the Circuit Court of Appeals heretofore entered in this [fol. 480] case, and was submitted to the Court. On consideration whereof, it is ordered, adjudged and decreed:

1. That letters patent of the United States, No. 1,172,322, issued to P. Torchio, February 22, 1916, for protective device for electric cable joints, and assigned to plaintiff Metropolitan Device Corporation, are good and valid in law.

2. That said P. Torchio was the first true and original inventor of the device and improvement described and claimed in said letters patent.

3. That plaintiff, Metropolitan Device Corporation, is the lawful owner of said letters patent.

4. That the defendant, The Cleveland Electric Illuminating Company, has infringed upon said letters patent, and particularly Claims 3 and 4 thereof, and upon the exclusive rights of the plaintiff under the same.

5. That a perpetual injunction issue out of and under the seal of this Court directed to said defendant, The Cleveland Electric Illuminating Company, its associates, directors, officers, attorneys, clerks, agents, servants and workmen enjoining and restraining them and each of them during the remainder of the term of said patent from directly or indirectly making or causing to be made, using or

causing to be used or vending to others to be used in any manner any articles, devices or apparatus containing, embodying or employing the said invention and improvements granted by the said letters patent, and particularly claimed [fol. 481] in said third and fourth Claims thereof, and from infringing upon or violating the said letters patent in any way whatsoever, provided, however, that in view of the fact that the infringing devices now in actual use by defendant on its lines cannot be immediately discontinued without damage and interruption of public service, defendant within thirty (30) days from the date of entry of this decree shall commence the removal and discontinuance of use of the infringing devices now in actual use on its lines and shall complete said removal and discontinuance of use by the 15th day of February, 1931.

6. That defendant do recover of the plaintiff its costs and disbursements in this court to be taxed and that plaintiff recover of the defendant its costs in the Circuit Court of Appeals.

THE UNITED STATES OF AMERICA:

Northern District of Ohio, Eastern Division

NORTHERN DISTRICT OF OHIO, EASTERN DIVISION

I, F. J. Denzler, Clerk of the District Court of the United States within and for said District, do hereby certify that I have compared the within and foregoing transcript with the original Final Decree entered upon the Journal of the proceedings of said Court in the therein-entitled cause, at the term and on the day therein named, and do further certify that the same is a true, full, and complete transcript and copy thereof.

Witness my official signature, and the seal of said Court [fol. 482] at Cleveland, in said District, this 29th day of January A. D. 1932 and the 156 year of the Independence of the United States of America.

F. J. Denzler, Clerk, by C. B. Williams, Deputy Clerk.
(Seal.)

PLAINTIFF'S EXHIBIT No. 10

Liber G148, page 374:

Assignment

Know all Men by These Presents That In consideration of the sum of One Dollar ($1.00) and for other good and valuable considerations paid by Arthur J. Perfler of Cleveland, Ohio to Metropolitan Device Corporation, a Corporation of the State of New York, receipt of which is hereby acknowledged, said Metropolitan Device Corporation has sold, assigned, transferred, and set over unto said Arthur J. Perfler, his successors and assigns, the entire right, title, and interest in, to and under Letters Patent of the United States No. 1,172,322, patented to Philip Torchio, February 22nd, 1916 for Protective Device for Electric-Cable Joints, and in and to the inventions and improvements therein set forth and claimed, subject to all licenses heretofore granted under said Letters Patent and now outstanding, and together with all rights and claims for damages and profit [fol. 483] which have resulted and are resulting from any and all past and present infringement of said Letters Patent, and the entire right to sue for and recover and collect any and all such damages and profits; the same to be held and enjoyed by said Arthur J. Perfler for his own use and behoof and the use and behoof of his successors and assigns to the full ends of the term for which said Letters Patent have been granted as fully and entirely as the same would have been held and enjoyed by said Metropolitan Device Corporation had this assignment and sale not been made.

In Testimony Thereof said Metropolitan Device Corporation has as of the first day of November, 1930 at Brooklyn, New York hereunto set its hand and seal by its executive officers hereunto duly authorized.

Metropolitan Device Corporation, by Thomas E. Murray, Jr., President.

Attest: Francis M. Fitzgerald, Secretary. (Seal.)

Recorded: Transfer of Patents, U. S. Patent Office, Apr. 20, 1931. Liber G148, page 374. Thomas E. Robertson, Commissioner of Patents.

[fol. 484] PLAINTIFF'S EXHIBIT No. 11

Liber G148, page 375:

Assignment

Know all Men by These Presents That In consideration of the sum of One Dollar ($1.00) and for other good and valuable considerations paid by the Electric Cable Joint Company, a corporation of the State of Ohio, having its principal office in the City of Cleveland, Ohio to Arthur J. Perfler, of Cleveland, Ohio, receipt of which is hereby acknowledged, said Arthur J. Perfler has sold, assigned, transferred, and set over unto the said Electric Cable Joint Company, its successors and assigns, the entire right, title and interest in, to and under Letters Patent of the United States No. 1,172,322, patented to Philip Torchio February 22nd, 1916 for Protective Device for Electric-Cable Joints, and in and to the inventions and improvements therein set forth and claimed, subject to all licenses heretofore granted under said Letters Patent and now outstanding, and together with all rights and claims for damages and profits which have resulted and are resulting from any and all past and present infringement of said Letters Patent, and the entire right to sue for and recover and collect any and all such damages and profits; the same to be held and enjoyed by said Electric Cable Joint Company for its own use and behoof and the use and behoof of its successors and assigns to the full ends of the term for which said Letters [fol. 485] Patent have been granted as fully and entirely as the same would have been held and enjoyed by said Arthur J. Perfler had this assignment and sale not been made.

In testimony whereof said Arthur J. Perfler has as of the 18th day of April, 1931, at Cleveland, Ohio, hereunto set his hand.

Arthur J. Perfler.

STATE OF OHIO,
County of Cuyahoga, ss:

On this 18th day of April, 1931 before me personally came Arthur J. Perfler, to me known and known to me to be the individual described in and who executed the foregoing instrument and he duly acknowledged to me that he executed the same.

L. S. Klein, Notary Public. (Seal.)

Recorded: Transfers of Patents, U. S. Patent Office, Apr. 20, 1931. Liber G148, page 375. Thomas E. Robertson, Commissioner of Patents.

[fol. 486] PLAINTIFF'S EXHIBIT No. 12

Received and Recorded in U. S. Patent Office; Jun. 16, 1922. In Liber W116, page 275 of Transfers of Patents. Thomas E. Robertson, Commissioner of Patents. Ex'd. M. B. K.

Assignment

Whereas, I, Philip Torchio, of the City, County and State of New York, did obtain United States Letters Patent number 1,172,322 for an improvement in "Protective Devices for Electric Cable Joints", dated Febraury 22nd, 1916:

And, whereas, Thomas E. Murray, of the City, County and State of New York, is desirous of acquiring my interest in said United States Letters Patent:

Now, therefore, to all whom it may concern, be it known that for and in consideration of the sum of One Dollar, to me in hand paid, the receipt of which is hereby acknowledged, I, the said Philip Torchio, have Sold, Assigned and Transferred unto the said Thomas E. Murray My Right, Title and Interest in and to said United States Letters Patent number 1,172,322; the same to be held and enjoyed by the said Thomas E. Murray, for his own use and behoof and for the use and behoof of his legal representatives, successors and assigns, to the full end of the term for which [fol. 487] said Letters Patent is or may be granted, as fully and entirely as the same would have been held and enjoyed by me had this assignment and sale not been made.

In witness whereof, I have hereunto set my hand and seal this 10th day of June, 1922.

Philip Torchio.

Jno. A. McNeon.

STATE OF NEW YORK,
County of New York, ss:

On this 13th day of June, 1922, before me personally came Philip Torchio, to me known and known to me to be the individual described in and who executed the foregoing in-

strument and duly acknowledged to me that he executed the same.

F. Jesser, Notary Public, Westchester County. Certificate filed with Register. Certificate filed N. Y. County 57, Reg. 3061. Commission Expires March 30th, 1923.

[fol. 488] PLAINTIFF'S EXHIBIT No. 13.

D. Anthony Usina, 71 Broadway, New York

Liber Q129, page 92. 2249:

Assignment

Whereas, by an assignment dated June 10, 1922, recorded June 16, 1922 in Liber W-116, page 275 of Transfers of Patents, I, Thomas E. Murray, of the City, County and State of New York, acquired from Philip Torchio of the City, County and State of New York, the entire right, title and interest in and to United States Letters Patent granted to him, No. 1,172,322, dated February 22, 1916 for an Improvement in Protective Devices for Electric Cable Joints.

Now, therefore, for One ($1.00) Dollar and other good and valuable considerations to me in hand paid, receipt of which is hereby acknowledged, I, the said Thomas E. Murray, have sold, assigned and transferred and do hereby sell, assign and transfer to Metropolitan Device Corporation, a corporation of the State of New York, its successors and assigns, the entire right, title and interest in and to the aforesaid Letters Patent; together with all claims, demands and causes of action arising out of past or future infringement of said Letters Patent.

In witness whereof, I have hereunto set my hand and seal this 11th day of February, 1927.

Thomas E. Murray.

[fol. 489] STATE OF NEW YORK,
County of New York, ss:

On this 11th day of February, 1927, personally appeared before me Thomas E. Murray, to me known and known to me to be the same person who executed the foregoing instru-

ment and acknowledged that he executed and delivered the same for the purposes therein stated.

William X. Seewagen, Notary Public. Notary Public, Queens Co. No. 3691. Cert. filed in N. Y. Co. No. 79, Reg. No. 7261. Commission expires March 30th, 1927. (Seal.)

Recorded: Transfers of Patents, U. S. Patent Office, Feb. 19, 1927. Liber Q129, page 92. Thomas E. Robertson, Commissioner of Patents.

[fol. 490] PLAINTIFF'S EXHIBIT No. 14

3823

UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK

In Equity. No. 5474

ELECTRIC CABLE JOINT COMPANY, Plaintiff,

vs.

BROOKLYN EDISON COMPANY, INC., Defendant

Order

Plaintiff, Electric Cable Joint Company, by its Solicitors, Usina & Rauber, having moved for an Order for leave to file interrogatories under Equity Rule No. 58, and the defendant having defaulted by non-appearance, it is

Ordered that the motion is hereby granted and that said interrogatories be answered by the President of the defendant company, or such other officer as may have complete knowledge of the matters inquired about, within fifteen days.

——— ———, United States District Judge.

Dated: March 18, 1932.

WXS:N.

[fol. 491] UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK

In Equity. No. 5474

ELECTRIC CABLE JOINT COMPANY, Plaintiff,

vs.

BROOKLYN EDISON COMPANY, INC., Defendant

Interrogatories

The following interrogatories by plaintiff are propounded to be answered by the President or other officer of the defendant having knowledge concerning the matters inquired about:

1. Which of the patents set up in paragraph 7 of the answer does defendant intend to introduce in evidence and rely upon at the trial?

2. Which of the publications set up in paragraph 8 of the answer does defendant intend to introduce and rely upon at the trial?

3. Which of the prior uses set up in paragraph 9 of the answer does the defendant intend to introduce in evidence and rely upon at the trial?

4. Referring to paragraph 18 of the answer, and to the statement therein that

[fol. 492] "said Metropolitan Device Corporation informed defendant that the patented feature distinguishing a high tension electric cable joint owned or controlled by it was a copper gauze stocking."

Was such information conveyed to defendant in writing?

4a. If so, what are the exact and entire contents of such writing?

5. Has the defendant prior to and within six (6) years from the filing of the bill herein used in its distribution system in Brooklyn an electric cable comprising one or more line conductors, insulating wrapping permeated with insulating compound and a sheath of lead, which cables

have been factory made and drawn through underground conduits?

5a. If so, produce a short section of such cable.

6. Where the line conductors of such cables have been jointed, was the joint of the construction which is described and shown in an article entitled "Joints in High-Voltage Multiple Conductor Cable", by Thos. F. Peterson, presented at the Summer Convention of the A. I. E. E., June 24, 1927, and particularly disclosed in the drawings on page 966 of that article, and in the description thereof, a copy of said article being attached hereto?

7. Accompanying the publication of the article by Peterson referred to in interrogatory 6, is a discussion a part of [fol. 493] which is by J. F. Fairman, pages 971 and 972. Was said Fairman at the time an engineer in the employ of the defendant company?

7a. Are the statements made in the discussion by Fairman referred to in interrogatory 7 above a correct statement of the construction and operation of defendant's joints at that time?

8. In the Electrical World of November 19, 1927, commencing page 29, there is an article entitled "Experience with Oil-Reservoirs for Preventing Voids in High-Tension Cable" by T. F. Peterson (Brooklyn Edison Company). Does this article correctly describe the construction and operation of the defendant's cables and joints in Brooklyn at that time? (Copy attached.)

9. If the defendant's cable joints and the methods of operation thereof have not within six (6) years prior to the filing of the bill herein been as described in the publications referred to in interrogatories 6, 7 and 8 above, in what respects have the construction and operation of the joints differed from the published description?

10. Besides the Brooklyn Edison Company, Inc., the defendant, is any other person, society, association, group, organization or corporation contributing to the defense of this suit or taking part in such defense through attorneys wholly or partly paid by itself or themselves?

[fol. 494] 10a. If so, give the names of any such persons, societies, associations, groups, organizations or corporations.

10b. Has the defendant, Brooklyn Edison Company, Inc., become or promised to become a member of any society, association, group, organization or corporation having as an object the attacking of the validity of the patent here sued on, or the defending of electrical companies against whom claim may be made under such patent?

10c. Has the defendant taken any part in the making up with others of a fund for the purpose of attacking the validity of the patent in suit or of defending electrical companies against whom claim may be made under such patent?

Note: The defendant by its President or other duly qualified officer is required to answer the foregoing interrogatories separately, fully and in writing, and under oath.

Usina & Rauber, Solicitors for Plaintiff.

Mar. 11, 1932.

Articles referred to in the preceding interrogatories are Plaintiff's Exhibits Nos. 21 and 22.

[fol. 495] Plaintiff's Exhibit No. 15

United States District Court, Eastern District of New York

In Equity: No. 5474

Electric Cable Joint Company, Plaintiff

against

Brooklyn Edison Company, Inc., Defendant

Defendant's Answers to Interrogatories

Defendant, by its Vice-President, Harry R. Woodrow, in answer to the interrogatories propounded by plaintiff, pursuant to the order of this Court dated March 18, 1932, says:

1. The answer to interrogatory No. 1 is: "All of the patents set up in paragraph 7 of the answer."

2. The answer to interrogatory No. 2 is: "All of the publications set up in paragraph 8 of the answer, except the patent and specifications therein contained in British patent No. 11,048 of 1891, issued to Walter Claude Johnson and Samuel Edward Phillips."

3. The answer to interrogatory No. 3 is: "Both of the prior uses set up in paragraph 9 of the answer."

4. The answer to interrogatories Nos. 4 and 4a is: "Yes, such information was conveyed to defendant in writing by [fol. 496] letter from Metropolitan Device Corporation to Mr. J. C. Parker, Vice President, Brooklyn Edison Company, dated May 23rd, 1927, a full and true copy of which, containing the exact and entire contents, is hereto annexed."

5. The answer to interrogatory No. 5 is: "Yes."

5a. The answer to interrogatory No. 5a is: "Sections of such a cable illustrating some of the cable so used by defendant can be seen at the office of Charles Neave, Esq., 20 Exchange Place, City of New York."

6. The answer to interrogatory No. 6 is: "Some of the joints were of the construction which is described and shown in the article referred to in this interrogatory, and disclosed in the drawings on page 966 of said article."

7. The answer to interrogatory No. 7 is: "Yes."

7a. The answer to interrogatory No. 7a is: "Yes, as to one type of construction then used."

8. The answer to interrogatory No. 8 is: "Yes, as to some types of construction used at that time."

9. The answer to interrogatory No. 9 is: "There were about 200 specifically different forms of joint construction used by defendant in the period mentioned. It is not un- [fol. 497] derstood that plaintiff desires an answer to this interrogatory describing all of these various joints in detail. If specific interrogatories referring to specific types of joints are asked, defendant will attempt to answer the same."

10. The answer to interrogatories 10 and 10a is: "General Electric Company, and General Cable Corporation are

contributing to the defense of this suit, and are participating in the control of the defense."

10b. The answer to interrogatory No. 10b is: "No, except as above stated."

10c. The answer to interrogatory No. 10c is: "No."

Brooklyn Edison Company, Inc., by Harry R. Woodrow, Vice-President. Monroe & Byrne, Solicitors for Defendant, Brooklyn Edison Company, Inc.

March 26, 1932.

STATE OF NEW YORK,
County of Kings, ss:

Harry R. Woodrow, being duly sworn, deposes and says: That he is Vice-President in Charge of Electrical Operations of defendant Brooklyn Edison Company, Inc.; that he [fol. 498] has read the interrogatories propounded by plaintiff pursuant to the order of this Court dated March 18, 1932, and has knowledge concerning the matters inquired about, and that the foregoing answers to said interrogatories are, and each of them is, true as he verily believes.

Subscribed and sworn to before me this 26th day of March, 1932. Allen H. Magill, Notary Public. Kings County Clerk's No. 756. Kings County Register's No. 3348. New York County Clerk's No. 839. New York County Register's No. 3M547. Term expires March 30, 1933. (Notarial Seal:)

Boston, Chicago, Detroit, Minneapolis, Pittsburgh, St. Louis, Philadelphia, Atlanta, Seattle

Metropolitan Device Corporation

Manufacturers of the Murray Protective Devices, 1250 Atlantic Avenue, Brooklyn, New York

May 23rd, 1927.

Mr. J. C. Parker, Vice-President Brooklyn Edison Company, 360 Pearl St., Brooklyn, N. Y.

DEAR MR. PARKER: Will you make your own tests of the Metrolatum Filled High Tension Cable Joint?

[fol. 499] Prove to your own satisfaction that this joint is stronger than the cable itself.

A Copper Gauze Stocking the patented feature is what distinguishes the Metrolatum Filled High Tension Cable Joint. This Stocking acts as an electrostatic shield and distributes equally the electrical stresses around the conductors.

Cable engineers are in agreement that the use of mineral oil compound for filling the cable joint, similar to that used for impregnating the cables, is beneficial, adds life to the cable and guards against failure. Metrolatum which is used for filling this High Tension Cable Joint which we manufacture, is a high grade mineral oil compound. It has high dielectric strength, (we guarantee 25,000 volts per 1/10 inch gap at 120° F.) and low dielectric loss.

One of the figures in a recent test, was an eight hour strain of 160,000 volts. The joint was made on three conductors 350,000 cm sector cable with 20 x 10 inches of insulation.

64.

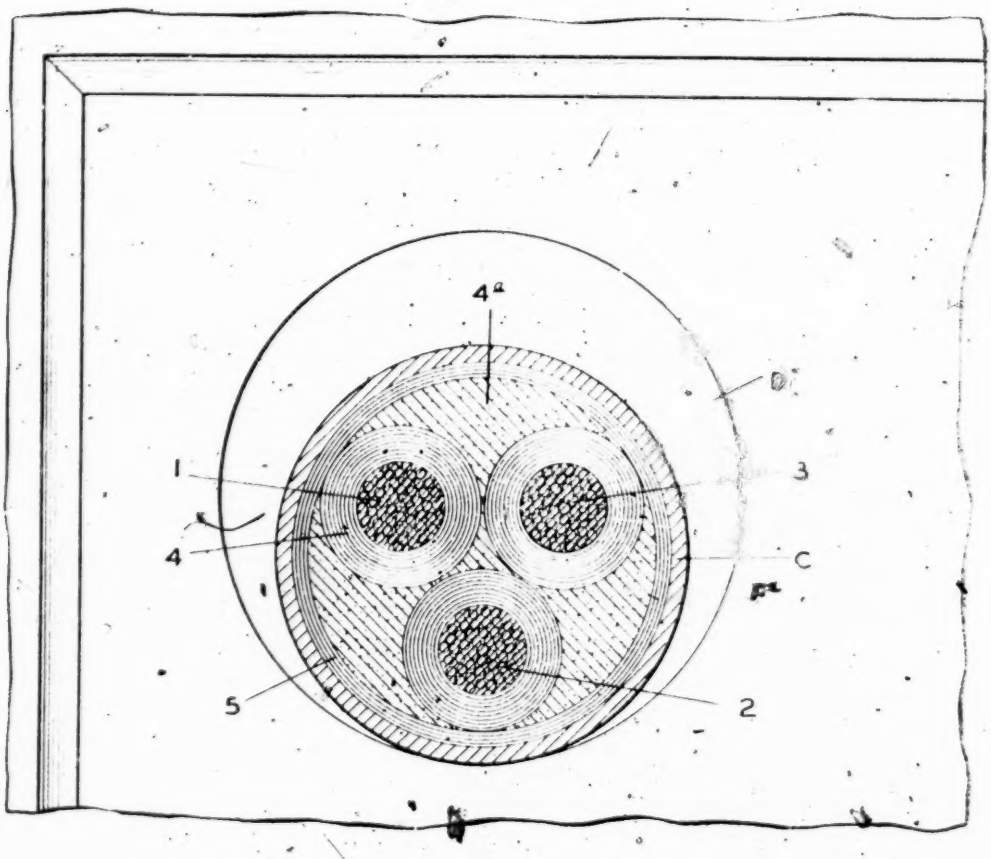
If we were not sure that the Metrolatum Filled High Tension Joint has decided advantages, do you think we would make this offer?

Very truly yours, Metropolitan Device Corporation,
J. B. Murray, Vice-President.

JBM:MGD.

PLAINTIFF'S EXHIBIT No. 16

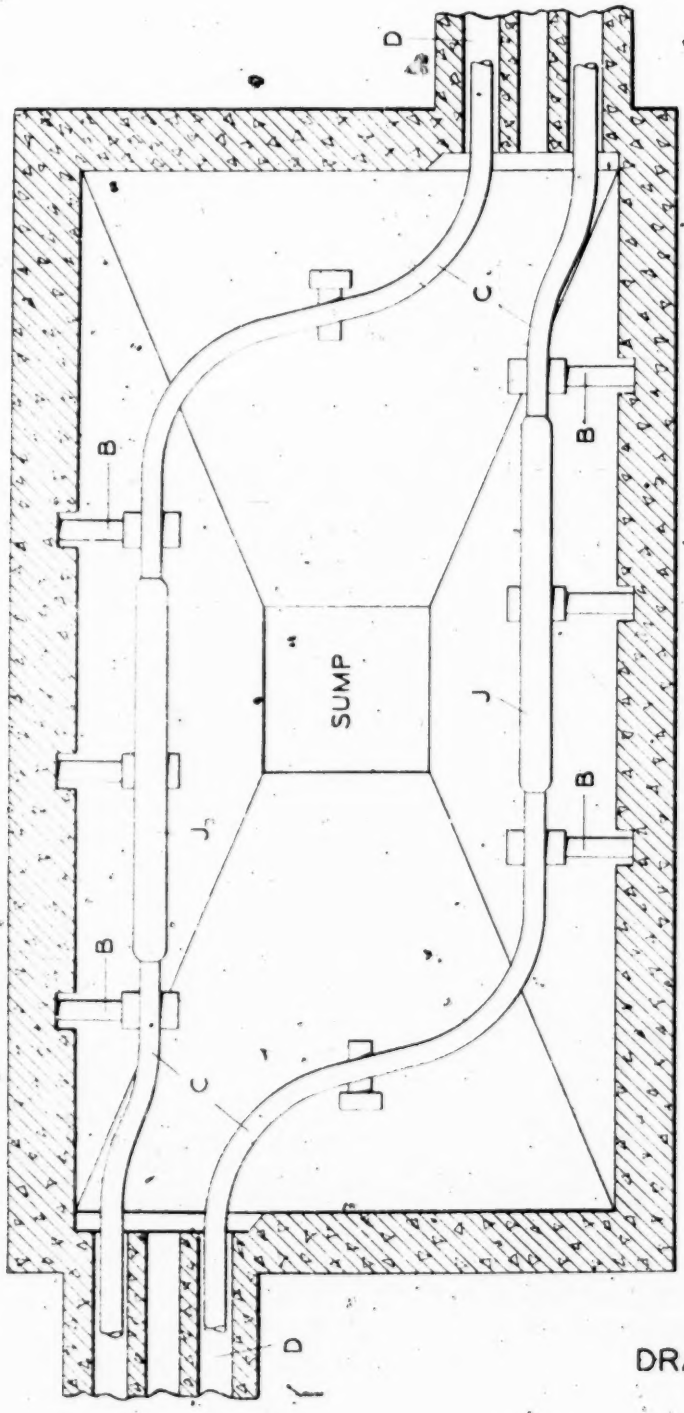
500



CROSS SECTION OF CABLE IN DUCT

DRAWING 'A'

501 PLAINTIFF'S EXHIBIT No. 17



HORIZONTAL SECTION

DRAWING 'B'

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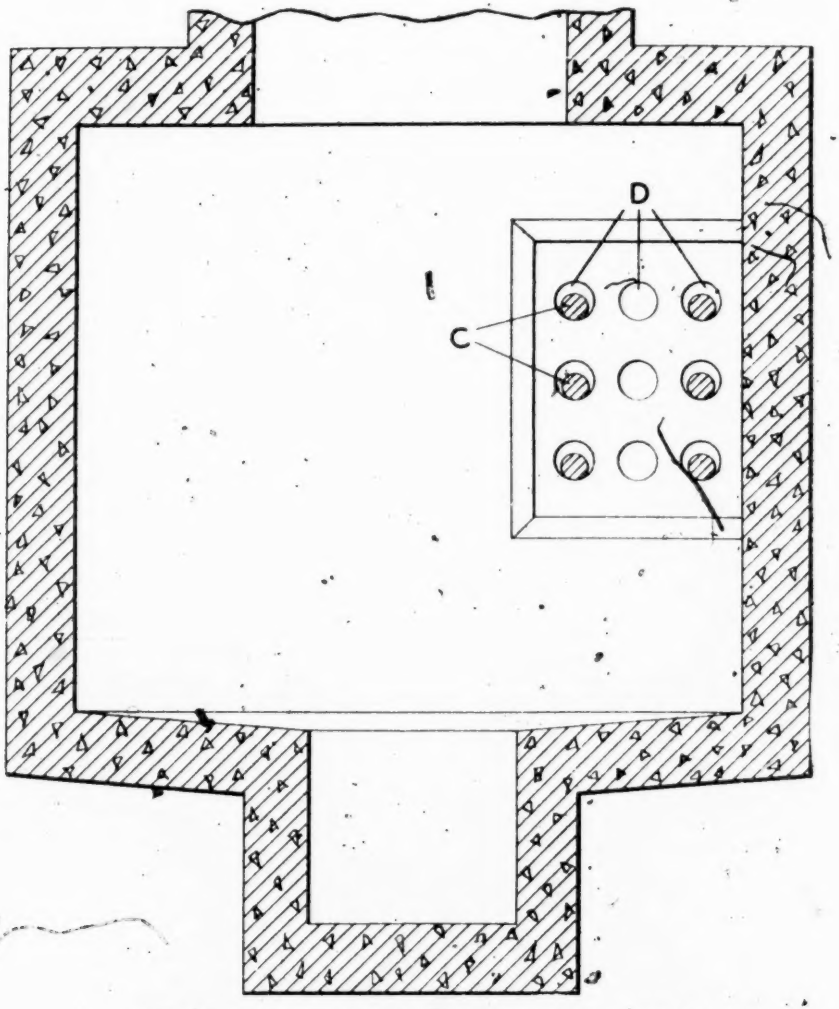
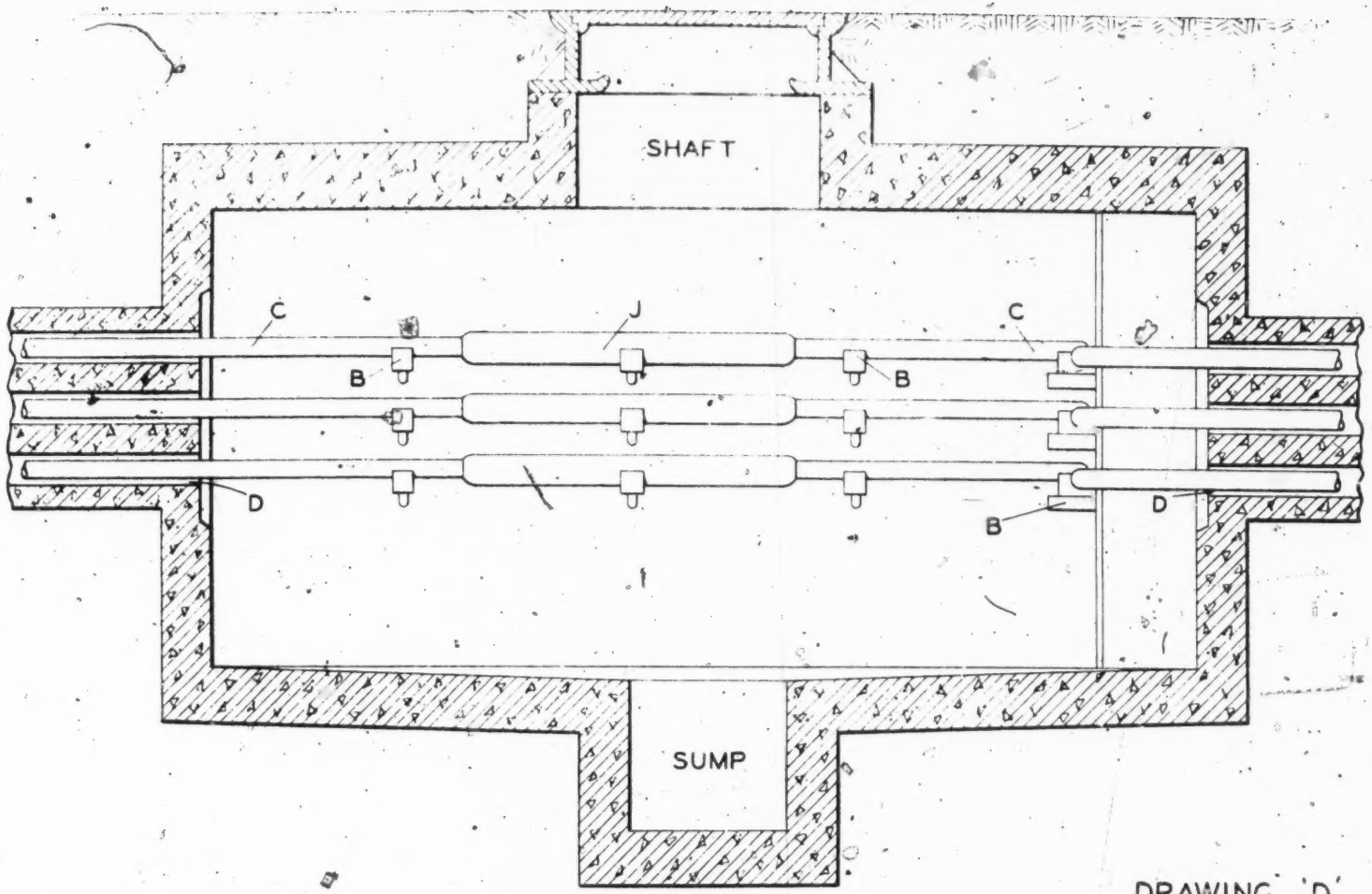


VERTICAL SECTION OF MANHOLE

DRAWING C

PLAINTIFF'S EXHIBIT No. 19



DRAWING 'D'

LONGITUDINAL SECTION

392

504

PLAINTIFF'S EXHIBIT No. 21

High-Voltage Multiple-Conductor Cable

BY THOS. F. PETERSON[1]

Associate, A. I. E. E.

Synopsis.—*In this paper the author has outlined the evolution of multiple conductor joints and explained in detail the development of a three-conductor, high-voltage joint for use with belted and metal sheathed cables or combinations of these.*

In the final design, spreaders and barrier tubes have been replaced by specially reinforced crotches and hand-wrapped insulation.

To date, all tests,—short time and accelerated life,—a-c. and d-c.,—have produced failures in cable rather than in joints so constructed.

Many other claims of superiority over existing types are presented.

LITERATURE on high-voltage cable theory, design, testing and operation is remarkably voluminous. This fact is especially noticeable when comparison is made with the meager data available on joints or splices and characteristics of jointed cable systems. Only recently have questions pertaining to the last mentioned been treated or emphasized in technical papers and discussions. It is quite pleasing however, to note their appearance in papers such as Del Mar's on the Effect of Internal Vacua, and others on the use of reservoirs and design of joints. This paper falls in the same category as the latter and constitutes a presentation of data on design, installation and operation of joints on high-voltage systems with which the author has been intimately associated.

In its final analysis a joint may be considered as a reconstruction of cable brought into being because it is physically impossible to maintain continuity of cable from one end of a feeder to the other. Most efficient design would dictate using a joint somewhat stronger electrically than the cable with which it is made. Except in a few cases, this is theoretically possible, although often it would appear as though "Brute strength" tactics were used in its accomplishment. Single conductor joints, those in metal sheathed and braided cable with immense amounts of insulation and those in multiple-conductor cable of monstrous size, typify these. The evolution of joints, with improvements gained partly from experience and more recently by the application of scientific principles of design, constitutes an extremely interesting subject for study.

When viewed in its entirety, one notices that the trend in joint design has followed rather closely that in cable design and quite justly so, since joint construction is, in a sense, cable reconstruction. When the old Edison tube was in use splices were made in enlarged coupling boxes, these being filled with hard compound as was the tube. Following this, various types of taped and rubber covered cable were developed. However, joints were made as before, except for the introduction of barrier tubes. Increase in operating voltage then gave rise to changes in impregnating compounds. At the same time difficulties with voids in hard compounds which were unavoidably produced during filling and with charring of paper, necessitated the use of such filling compounds as petrolatum and the introduction of hand wrapping, still however, retaining the barriers. In more recent developments based on knowledge of cable breathing, migration of compound into cable, stress distribution, etc., oil and reservoirs have been used at joints, barriers eliminated, crotches reinforced and, from one point at least, it would seem that joint construction has overtaken that of cable inasmuch as very little oil filled cable has as yet been placed in operation.

It is quite evident that in old designs, creepage paths were considered as the most important factors determining dielectric strength, this probably being derived from experience with joints on d-c. systems in which moisture, condensation, poor workmanship, impurities

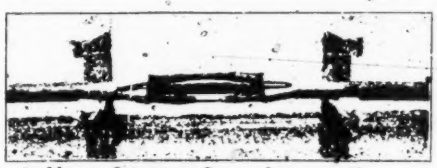


FIG. 1—METAL SHEATHED CABLE JOINT IN CONSTRUCTION

and the like contributed largely to failures. There seemed to have been no regard for stress distribution, dielectric constant relations of insulating materials and so we find barriers, tubes, porcelain, mica, paper, compounds, etc., in series with one another in various proportions and placed indiscriminately in the electric fields. These statements are not intended to belittle the importance of leakage paths but rather to encourage consideration of all phases of design.

Quite general practise today consists in operating with alternating current and testing with direct current. Under alternating potentials at standard frequencies, the dielectric stress distribution is dependent on the configuration of electrodes and the constants of the dielectric circuits. On the other hand such distribution exists only at the moment of application of direct or steady potential differences. After this, redistribution takes place in the form of a slow transient with end conditions depending on the resistivities of paths. If then, total stress is sufficiently high, failure will occur along the path of minimum resistance. Though the

1. With the Brooklyn Edison Co., Inc.

To be presented at the Summer Convention of the A. I. E. E., Detroit, Mich., June 20-24, 1927.

stress distribution under alternating current is determined primarily by dielectric constant relations, a component may always be determined acting in the direction of the leakage path and tending to produce this type of failure. It is obvious that the direct potentials with total voltage applied to path, are more severe. However, it is felt that defects brought to light by the comparatively high tests based on cable requirements are well worth removing and that the testing does not necessarily invite trouble. The importance of consideration of leakage paths as well as dielectric constant relations is thus brought out.

While the company with which the author is connected, was contemplating operation at 27 kv., many tests were made on multiple-conductor joints. Inasmuch as this was done under pressure of time no radical departures from standard types or accepted practises were made. Finally, one, hand wrapped, petrolatum filled, with porcelain spreaders and mica barrier tubes was adopted. Results with this type were fairly satisfactory. After several years of operation, however, a rather high percentage of failures was experienced on test which, on examination, were almost all found to have started at connectors, then continuing along pencilling and conductor insulation or barrier tubes to ground. These were due to such causes as follows:

1. Copper dust produced by filing connectors.
2. Jagged pencilling of conductor insulation.
3. Wrinkled conductor insulation. (2 and 3 giving rise to voids).
4. Compound having been driven from mill insulation at pencilling by heat during sweating of connectors.
5. Migration of compound into cable, making most probable location of voids on contact surface between mill insulation and hand wrapping.
6. Sharp edges of solder, connectors, etc.

It is quite obvious why, with such causes as these conspiring to produce trouble, direct-current tests, at 95 kv., conductor to ground, and 135-kv., conductor to conductor, were so effective in weeding out defects.

The cures for these evils were soon found. Advances were made in cable manufacture, (wrinkles being practically eliminated), pencilling was improved, one or two layers of varnished cambric tape was used over connectors, etc. These, with pressure filling, gave rise to a fairly satisfactory joint but, like "Champions and Records," this did not stand long, for tests at the laboratory under three-phase, alternating current revealed other weak places, namely, at the crotches and porcelain spreaders. Just about this time one Company whose experience in this direction was very similar to ours began to experiment with wooden spreaders, the idea being that with a dielectric constant more nearly equal to that of impregnated paper better results would be obtained. Our progress was along different lines.

For some time manufacturers and those engaged in testing of cable had suffered a serious handicap in not being able to carry tests of three-conductor cable to satisfactory completion because of breakdowns which invariably occurred at the crotches. The author was confronted with and quite successfully solved this problem about 2½ years ago. Examinations of crotch failures of cable tested under oil indicated that there were three outstanding causes for these, namely:

1. Ruptured conductor insulation due to sharp bending.
2. Breakdown of film of oil and then paper at crotch.
3. Circumferential stresses on conductors.

The first was removed by fanning out legs in stages, that is, removing part of belt and bending legs, using edge of belt as a fulcrum.

The second did not yield so readily to the corrective measures applied. The attack was based on observations made during two tests devised to bring out the existance of this cause.

A roll of impregnated tape was used as a spreader in

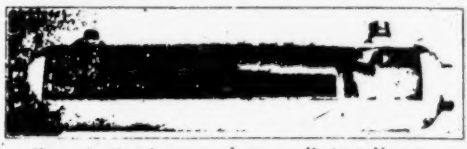


FIG. 2. CUT-AWAY OF JOINT IN BELTED CABLE

Joints of this type tested, 120-kv. three-phase, 10-65 hours.
Failures in cable, 130 kv., 15 hr. and 276 kv., instantaneous failure in cable.

a crotch. After application of three-phase voltage, the roll was badly burnt due to breakdown of oil at its center. At another time a sample was prepared and the crotch placed in a glass jar of clear oil. Spark discharge across film of oil in crotch was very much in evidence.

The dielectric constant of oil is approximately 2.5 and that of impregnated paper 3.2 to 4.1. When insulations are in series in a dielectric circuit distribution of stress is in inverse proportion to dielectric constant. It is seen, therefore, why oil or compound was stressed beyond its rupturing strength, broke down and the resultant heating, charring, etc., finally culminated in breakdown of adjacent paper.

Circumferential stresses on conductors manifested themselves by the appearance of tree formations at crotches through several layers of paper on the backs of conductors of certain types of cable, though these very rarely resulted in failure.

A rather simple solution for the above difficulties was arrived at after making some exhaustive tests using barriers, cotton and the like jammed into crotches, short circuiting oil by wrapping legs with electrostatic shields, using wrapping of wick. Finally, after carefully

2 See author's discussion of paper on a 132-kv. joint, by D. M. Simons, presented at A. I. E. E. Winter Convention, 1927.

bending conductors, each leg was built up conically with black varnished cambric tape starting deep in the crotch and extending out 5 inches, the maximum thickness being $\frac{3}{8}$ in., 4 inches from belt edge. (See Figs. 2 and 4). The conductors were drawn together and a varnished cambric belt was applied at crotch to the level of the factory belt. Then the lead sheath of cable was extended, using lead foil, to the point of maximum thickness of varnished cambric. The lead foil and varnished cambric belt were punctured to allow oil to enter where normally fillers would be. With this type of construction, overstressed oil films at crotch were replaced with varnished cambric. The latter with its high dielectric constant (approximately 5) in comparison with impregnated paper (approximately 3) assumed very little of the total stress between conductors, but still took a sufficient per cent to relieve the paper at crotch and make the stress in it considerably lower than in the rest of the cable. The foil served to eliminate circumferential stresses by maintaining a zero potential surface at a distance outward from the center of the conductors equal to the distance inward to the actual neutral axis of the cable. Similar crotches were used in testing metal sheathed cables, except that after building up individual legs with varnished cambric the metallic tape of cable was extended and carried over each leg to the point of maximum thicknesses of varnished cambric (see accompanying illustrations).

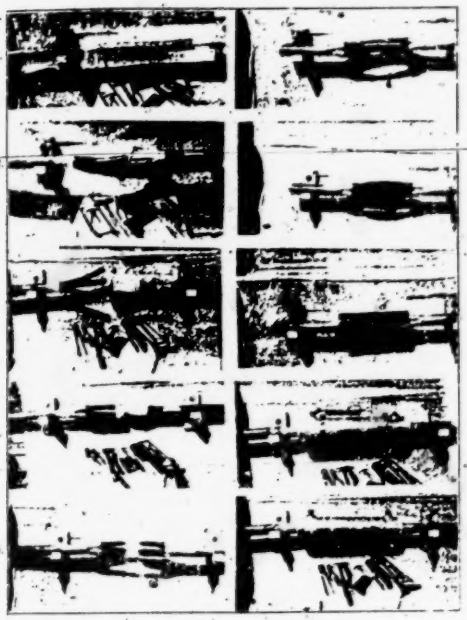


FIG. 3—SHOWING STAGES OF CONSTRUCTION

1. Cable butted
2. Fanning conductors
3. Conductors covered with one layer of tape
4. Crotch built up, metal foil applied
5. Connectors sweated
6. Hand wrap
7. Hand wrap
8. Barrel slipped into place
9. Pressure filling
10. Cap on—completed joint

Results with this construction were highly satisfactory yielding failures in cable after runs of 35 to 50 hours at 120 kv., three-phase as compared with 3 to 8 hour crotch failures previously obtained and so it was recommended for use in crotches of joints on our 27 kv. system. In the latter role, the applied varnished cambric served not only as a reinforcement, but also as spacer, thus eliminating another objectionable features of existing joint, namely, the porcelain spreader. (See Fig. 4).

Before its adoption for use in connection with metal sheathed cable, comparative high-voltage tests were made on joints in which metal foil was ended at crotch, *i. e.*, cut off and tied down, carried across connectors, over hand-wrapped insulation, etc. In all these, the decided superiority of the built up construction was shown. Joints with metal tape carried across the hand-wrapped insulation failed after about twenty minutes at 120 kv., while those with tape ended at crotch were but a little better. In the first, failures occurred across stepped and conical penciling. This type of joint would seem unsatisfactory at first sight (despite the fact that some manufacturers stand by it because radial stresses are maintained throughout) since filling compound is of no avail in taking up stress and the total voltage is applied to a comparatively weak path between pencil and hand wrapped insulation. Joints made in manner described, that is, using built up crotches, have withstood tests at 120 kv. for 10 to 60 hours without failure. In all cases rupture has occurred in cable. This is quite favorable, when compared with the results obtained on standard Conducell joints which have averaged 3 to 10 hours at 120 kv., three-phase.

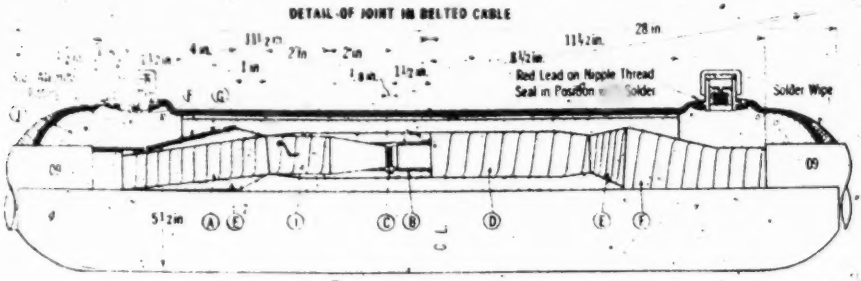
Hand wrapping of joints with tape has always been a long and tedious operation in which the personal equation of the worker is a most important item.

Prior to making the aforementioned studies and tests, an attempt was made to reduce manual labor involved in joint construction by substituting barrier tubes and spacers made of bakelite and the like, for the hand wrapping. Results of voltage tests were very discouraging since failures occurred at 120 kv. after from one-half to one hour, the higher values being obtained with the thinner tubes. Careful examination and investigation indicated that such devices which had high dielectric constants and were of such shape as to place small thicknesses of compound in series with them thus greatly overstressing the latter, were of no use and should be avoided. Barrier tubes were accordingly eliminated from final design (see Figs. 4 and 5) and some additional paper hand wrap was applied over connectors,

...ever, consider the fact that the ... serves as the dielectric instead of compound and ... makes it pos... to ... ream comparatively long paths ... thus increasing strength of joint, ... ing component parts.

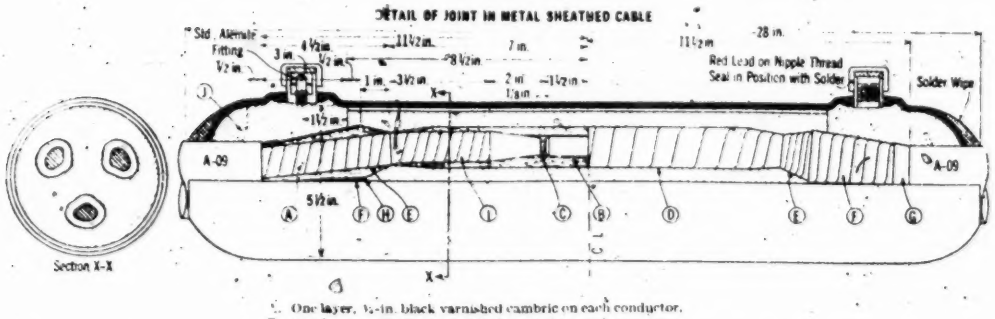
Commercial test results similar to those recorded ... 95-kv. ... direct potential differences, conductor to ground, have been made without the slightest indication of any developing failure. These data, together with very satisfactory operating experience serve as evidence for claims of superiority of this joint.

Joints installed in practise do not differ materially from



A. One layer, ¼-in. black varnished cambric on each conductor.
B. One layer, ¼-in. black varnished cambric on each connector.
C. Varnished cambric strips 1/8 in. to ¼ in. wide to level of connector diameter.
D. Paper tape.
E. ¼-in. black varnished cambric conical wound as shown.
F. One layer, 5/8 in. lead foil around all three conductors.
G. Black varnished cambric around all three conductors.
H. Varnished cambric 5/16 in. thick 4 in. from bell.
I. Remove ... tape 2 in. from edge of pencil, also one layer of conductor insulation before applying paper tape.
J. Bell to be beat into original position after crotch is finished.

FIG. 4—SPECIFICATIONS FOR 3-CONDUCTOR, 27,000-VOLT, 09 CABLE JOINT 27-3



A. One layer, ¼-in. black varnished cambric on each conductor.
B. One layer ¼-in. black varnished cambric on each connector.
C. Varnished cambric strips 1/8 in. to ¼ in. wide to level of connector diameter.
D. Paper tape.
E. ¼-in. Black varnished cambric conical wound as shown.
F. One layer, 5/8 in. lead foil on each conductor from highest point to bottom of crotch and in contact with copper foil on conductors.
G. 5/8 in. lead foil two layers around all three conductors and in contact with outer metallic tape of cable.
H. Varnished cambric 5/16 in. thick 4 in. from bell.
I. Remove ... tape 3 ... in. from edge of pencil, also one layer of conductor insulation before applying paper tape.
J. Bell to be beat into original position after crotch is finished.

FIG. 5—SPECIFICATIONS FOR 3-CONDUCTOR, 27,000-VOLT, A-09 CABLE JOINT, 27-3

have recently been obtained by another of the Metropolitan companies which has adopted this type of joint for metal-sheath cable. In addition to the above alternating-current tests, run of five hours duration at those described. Conductors are carefully fanned out and covered with one layer of tape to exclude foreign matter, crotches are built up, connectors are sweated, insulation pencilled conically (approximately 2 in. long) and sand-

papered. Then gaps between insulation and connectors are built up with thin strips of varnished cambric and one layer is applied over connector. One layer of mill insulation is removed from conductors and finally each leg is built up with hand-wrapped tape. An insulating barrel is used inside of lead sleeve, merely for mechanical protection and joint is either pressure filled with petrolatum, or oil filled and equipped with a collapsible reservoir or the like. Though this joint is somewhat more difficult to make than the usual type and depends quite largely on the ability of the splicer, little difficulty is experienced in the field, when men are properly trained.

In the foregoing we have been concerned more particularly with electrical rather than mechanical characteristics of joints. The latter, however, are of immense importance. Absolute cleanliness should be exercised. Wipes, plugs and material must be such as to insure against introduction of moisture. Though voids are not likely to exist at time of filling, they may develop in practise, hence fittings, location in manholes, etc., must be arranged to facilitate periodic inspection, refilling of joints, or installation of reservoirs. These can best be dealt with as individual problems.

Summarizing, then, it may be said that a joint has been developed having high leakage resistance, good stress distribution and on which our test results, both alternating-current and direct-current, and operating experiences, are quite satisfactory. (Note: No studies have been made of dielectric loss because to date nothing in our experience has indicated the need for consideration of same). Furthermore, barriers and spreaders have been eliminated and a zero potential surface has been established around the crotch which gradually extends out toward sleeve, thus tending to maintain radial stresses throughout joint. In addition, due to removal of tubes, phasing out of cables is more easily accomplished since conductors in joint do not have to be run parallel to cable. Instead of having two bends in the conductors one at each end of the joint, and then a straight run through cells or tubes as is necessary in the barrier type joint, the lay or twist may be continued through the joint. Last, and perhaps most important, is the universality of the joint. Not only can it be used with belted cable and metal sheathed cable, round or sector conductor, but also with combinations of these.

It is not intended that these statements be construed to mean that perfection in joint design has been reached. The author expects to attempt improvements from time to time and profit by criticism which will undoubtedly accompany its more general adoption.

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PLAINTIFF'S EXHIBIT No. 22

Experience with Oil Reservoirs for Preventing

Voids in High-Tension Cable

Brooklyn Edison Company finds them very satisfactory with 27-kv. cable system. Old cables rejuvenated. Details of installation

By T. F. Peterson

Brooklyn Edison Company

WHEN the 27-kv. system of the Brooklyn Edison Company was begun in 1922, the paramount idea influencing the design and manufacture of cable, as well as its subsequent installation, was that voids and moisture were largely responsible for cable and joint failures. Accordingly, provisions were made to maintain pressure within the cable above atmospheric at all times by means of suitable reservoirs at the high points of feeder lengths; in this way insuring against the existence of voids or the entrance of moisture and air. Before making any installations an extensive program of research was carried out covering the migration of compound in cable and the design of proper reservoirs and stop joints.

In order to determine the extent of compound movement that could be expected in installed cable, a 240-ft. length of three-conductor 250,000 circ.-mil-$\frac{17 \times 11}{64}$ paper-insulated cable was coiled in a vertical helix on a 7-ft. diameter drum, 8 ft. high. Compound levels and pressures at conservators on cable ends were carefully observed during temperature cycles. Results of these tests indicated that, following the initial filling of voids (formed during bending) that took place at the first heating, there was very little movement. Furthermore, no sheath expansion could be detected during these temperature cycles (24-hour period and 55 deg. C. maximum sheath temperatures). The general conclusion drawn at that time was that, under the ordinary conditions of a sealed cable system, migration was not a matter of much concern. On the other hand, it was quite evident that a break in a lead sheath at a low level could result in the slow bleeding of cable. In view of these conclusions it was deemed unnecessary to proceed further with the design of a stop joint. However, steps were taken to obtain data on migration in installed cables. An attempt was made to determine the magnitude of forces prompting the movement. In some cases pressures of + 3½ lb. per square inch at low levels and − 3 lb. per square inch at high points were found to exist.

Following this, the first practical means to provide for breathing of potheads, maintenance of internal pressure and replenishment of oil to cable were installed. These consisted of sections of 5-in. pipe fitted with weighted plungers, capped at both ends and piped to transformer potheads. (See Fig. 1.) When filled with petrolatum or a mixture of petrolatum and transil oil, they served exceptionally well to compensate for volume changes incidental to temperature variation and absorption of the compound by the cable. These crude reservoirs have since been replaced by our present-day methods of replenishing oil of potheads by piping to transformer tanks and conservators.

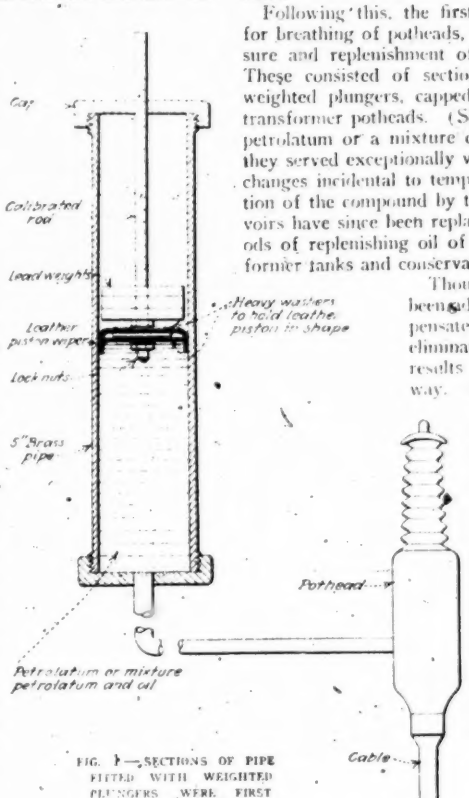


FIG. 1.—SECTIONS OF PIPE FITTED WITH WEIGHTED PLUNGERS WERE FIRST USED AS RESERVOIRS

Though these could probably have been adapted to 27-kv. joints to compensate for volumetric changes and eliminate vacua, it was felt that better results would be obtained in another way. Early in 1924 twenty collapsible bellows-type reservoirs filled with petrolatum were installed at the high joints of feeders. These were inspected at regular intervals. Changes in height were such as to indicate very slow migration. Subsequently other weighted bellows, some filled with petrolatum and others with oil, were added. These remained for approximately two years. At the end of this time considerable evidence substantiating migration theories was obtained. Many of the reservoirs were entirely devoid of oil; others contained large voids. The results were in entire agree-

Oil Reservoirs Used at Every Manhole on High-Tension Cable System

DURING the past five years an energetic program of cable and insulation research has been in progress in the Brooklyn Edison Company. The results, though by no means final or complete, have been very gratifying and have been reflected in the marked improvements made in cable performance. This improved performance is due both to better manufacture of cable and to progress and refinement in handling, jointing, testing and maintaining cable made by the operating company. One of the most important features in this progress has been the introduction of oil reservoirs on potheads and joints of cable which are operating at 27,000 volts.

In the early stages of the redesign of the transmission system of the Brooklyn Edison Company in 1922 it was determined to make 27,000 volts the basic transmission pressure for future developments. Before placing this system in operation a great deal of thought and study were given to the various factors of cable design and method of testing and jointing cables. In this analysis three fundamental factors essential to the good performance of the cable system were brought out. Thorough oil impregnation, elimination of moisture and elimination of air voids. It was found that cable could be manufactured that had these three characteristics in good shape at the time of testing in the factory, but subsequent handling, permitting oil leakage from the cable, air and moisture entrance and the continuous absorption of oil into the paper fibers, would result in inferior cable when installed in the duct system. After a cable is operated with its heating and cooling there is migration of oil in the cable, and although of very slow movement, it may be very effective in causing deterioration. Vacua of considerable magnitude have been found within cable when the lead caps are moved for installing. This condition allows the plugging in of considerable air with its entrapped moisture.

As a result of this analysis the Brooklyn Edison Company adopted the policy, at the initial installation of the 27,000-volt system in 1922, of installing oil reservoirs on the cable system wherever possible. These reservoirs were first installed at the transformer and substation switch connections with the hope of insuring a positive pressure above atmosphere throughout the cable system at all times. It is self-evident that, with the pressure maintained above atmosphere and oil for filling in voids, any leak that might occur would cause a leakage from cable to the outside which could be detected before moisture could leak into the cable. It was found that the migration of oil throughout the cable was so slow that these reservoirs on the transformer potheads were not sufficient to maintain a positive pressure throughout any great length of cable, and the next step was to introduce reservoirs at the joints within the manholes.

This practice has been expanded until it is a very general custom to use reservoirs on 27,000-volt cable joints in every manhole on the cables the company is installing at the present time, and to go back over all of the older cables and install reservoirs in locations where inferior cable is installed.

The accompanying paper by Mr. Peterson gives the development of this principle on the Brooklyn Edison system, and it is of interest to note that it has been possible to rejuvenate old cable, which would not stand up under 27,000-volt operation, to such an extent as to make it a very reliable 27,000-volt cable.

ment with observations of a different character—for example, (1) collapse of joints was being reported by some companies; (2) the local system experienced a great number of joint failures apparently due to lack of compound despite the fact that filling was once complete; (3) joints could be refilled—that is, would allow addition of compound at six-month intervals. (Incidentally, this practice greatly reduced the number of failures obtained.) Only one conclusion could be reached, and that was that compound did migrate.

Voids and Air Pockets in Cable and Joints

The early statements and ideas on internal cable pressure were what one might call "over-all" or "boundary" contentions. They dealt not so much with the detailed mechanism of the creation of voids, air pockets, etc., but

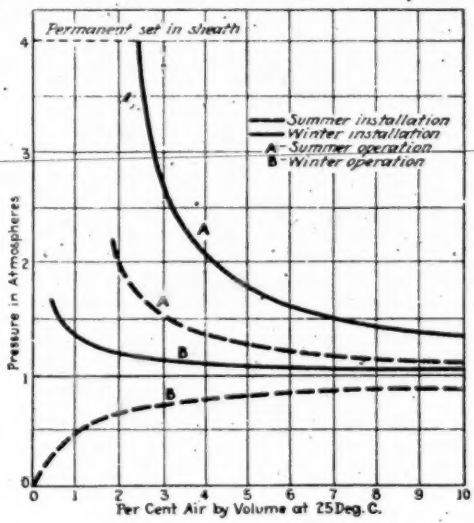


FIG. 2—PRESSURE VERSUS PERCENTAGE AIR CURVES FOR CABLES AT VARIOUS OPERATING AND INSTALLATION TEMPERATURES

more particularly with the development of a means to prevent or compensate for them regardless of cause. A complete study of reservoir use should, however, include some discussion of the characteristics of jointed cable systems.

Initially, all cable contains a certain percentage of air, the amount varying with the method and materials of manufacture. If the temperature of installation of the cable is less than that at the factory when sealing is done, the percentage may be increased by the inflow of air when caps are broken. If the installation temperature is greater than that at the factory, a readjustment will take place in such a way as to make the pressure and volume of the initial mass of air correspond to the temperature of installation. In this connection it might be well to note that if cable were sealed at a lower temperature than installation best results would be obtained, for then compound will be lost rather than air taken in. Pressure-percentage air curves for various operating and installation temperatures are shown in Fig. (2). The author's derivations of equations for these are given in the box on page 1031. Graphs similar to these were first

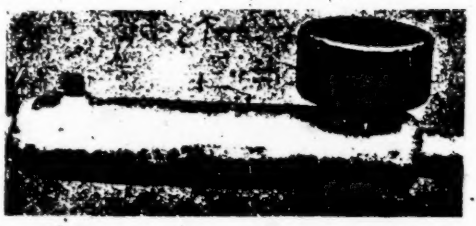


FIG. 3—TYPE OF OIL RESERVOIR USED ON 27-KV. CABLE JOINTS

presented to the A.I.E.E. by C. F. Hanson.[1] Curves above the atmospheric line indicate temperatures of operation higher than those of installation; the greater this difference the higher the curve. In the case of the curve below atmospheric the reverse is true.

Small percentage of air cannot compensate for expansion or contraction of the compound without extreme pressure changes. This is indicated by the shapes of the left ends of the curves. In actual practice these curves are shifted considerably by the action of certain indeterminate factors—for example, those tending to lower curves—that is, increase vacua:

1. Working cable into ducts causes permanent sets in lead sheath and thus increases percentage of air pocket.
2. Repeated expansion and contraction with temperature may also do this.
3. Cheese or "X" formation is accompanied by contraction in volume of compound. It matters little whether a void exists first and that cheese formation is incidental to ionization of this or whether it forms first; a contraction takes place irrespective of sequence.
4. Some have attributed dryness of old cable to the slow absorption of oil by paper fibers. This may or may not be an important item.

Those tending to raise curves—that is, increase pressure:

1. Opening joints when cable is under vacuum.
2. Pressure filling of joints.
3. Refilling joints. (This should preferably be done during cold weather.)

In most cable systems the void- or vacua-creating tendencies are by far the most important. The effect of these are very clearly treated in a paper by Mr. Del Mar.[2] After consideration of this and study of the curves of Fig. 2 it might appear that large percentages of air in the cable were to be preferred because of their pressure stabilization (a small percentage of either giving rise to vacua or accompanied by higher pressures and permanent sets which eventually would cause vacua). However, this is not the case. Large amounts of air—that is, air in fairly appreciable thickness—will ionize even at atmospheric or slightly higher pressures, when the gradients in the cable are quite low. On the other hand, small amounts, possibly finely divided, will not ionize, even under appreciable vacua at same gradient.[3]

Obviously the most desirable condition would be to

[1] Discussion of paper on "Effect of Internal Vacua," by Del Mar, A.I.E.E., 1926.

[2] Paper on "Effect of Internal Vacua," Del Mar, 1926.

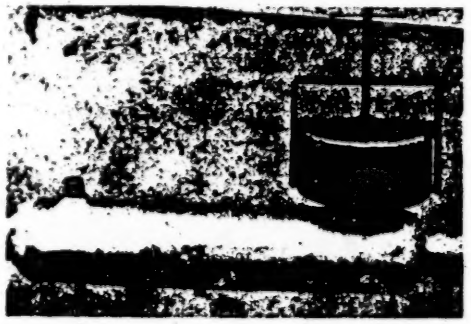


FIG. 4—CABLE OIL RESERVOIR WITH EXPANDING DEVICE

[3] See page 83 of book entitled "Electric Cables," by Del Mar.

Study of Pressure Variation with Temperature in Jointed Cable Systems

Let a be percentage of air by volume in cable at cable factory; temperature, 25 deg. C.
t_1 the temperature of installation
t_2 the temperature of operation
Let b be percentage of air by volume in cable at installation temperature
$(1 - b)$ is percentage of compound
(Percentage expressed as decimal)

If the temperature coefficient of expansion of the compound is assumed to be 0.001, the change in the volume of the compound $= (1 - b) \times 0.001 \times (t_2 - t_1)$

The volume of air is decreased by this amount and becomes $V_2 = b - (1 - b) \times 0.001 \times (t_2 - t_1)$

(1) But for gases $pV = RT$

and $$p_2 = p_1 \times \frac{V_1 (t_2 + 273)}{V_2 (t_1 + 273)}$$

$$= p_1 \frac{273 + t_2}{273 + t_1} \times \frac{b}{b - (1-b) \times 0.001 \times (t_2 - t_1)}$$

This is a general expression and can be used for any changes of temperature—that is, + or −.

If the cable is sealed at the factory with a percentage of air at, say, 25 deg. C. and opened for winter installation at temperature t_1, air will enter the cable to compensate for contraction of the compound

$$b = a + (1 - a) \times 0.001 \times (25 + t_1)$$

This expression must be substituted in (1). Assuming $t_1 = 15$ deg. C. for winter installation,

$$b = a + (1 - a) \times 0.01$$

and $$p_2 = p_1 \times \frac{273 + t_2}{273 + 15} \times$$

$$\frac{a + (1 - a) \times 0.01}{a + (1 - a) \times 0.01 - 1 - a - (1 - a) .01 \times .001 (t_2 - 15)}$$

(2) $$p_2 = p_1 \times \frac{273 + t_2}{273 + 15} \times$$

$$\frac{0.99a + 0.01}{0.99a + 0.01 - (1 - 0.99a - 0.01) \times 0.001 \times (t_2 - 15)}$$

Now it is necessary to substitute values for t_2 depending on operating conditions, as for example, $t_2 = 40$ deg. C. for maximum load in summer and $t_2 = 20$ deg. C. for minimum operating temperature in winter.

Curves showing the $(p - a)$ variation are then drawn.

Summer Installation

If the cable is installed in summer at approximately 30 deg. C., the compound will flow from the cable making air at atmospheric pressure for temperature 30 deg. C. instead of 25 deg. C.

The percentage of air, $b = a - \frac{273 + 30}{273 + 25} = 1.017a$

(3) This value of b when substituted in (1) yields

$$p_2 = p_1 \times \frac{273 + t_2}{273 + 30} \times$$

$$\frac{1.017a}{1.017a - (1 - 1.017a) \times 0.001 \times (t_2 - 30)}$$

Curves drawn with $t_2 = 40$ deg. C. for maximum summer operation and $t_2 = 20$ deg. C. for minimum winter operating temperature are also drawn.

have the relative volume of voids and air as low as possible and provide some means for pressure stabilization above atmospheric. This may be accomplished without the disadvantages mentioned by the use of a large volume of air in a sealed tank reservoir, partly filled with oil. The gas may or may not be under pressure. In this way the desirable features of a large percentage of air are

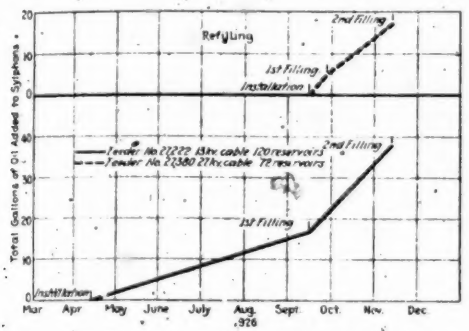


FIG. 5.—RECORD OF OIL RESERVOIR FILLING ON CABLE JOINTS

obtained without the incidental disadvantages. Equivalent and, what we think better results may be obtained by the use of weighted collapsible reservoirs of the bellows type. It is recognized that these must be of suitable design. In this use of the device volume change is much more important than ability to operate at high pressure, relatively high frequency of movement or under heavy loads. These points have received due consideration in the design of equipment installed.

There are some inherent differences between these two methods. If the air bell type is left with air at atmospheric pressure, subsequent temperature changes may result in quite wide variation, above and below atmospheric. If the relative change is to be limited, the initial pressure must be quite high. This, too, has disadvantages. Then again, with air, there is danger of condensation of moisture, resulting in oil impairment, possibility of getting air into the cable system, need for gages to determine oil level, etc. On the other hand, with a weighted bellows a constant pressure somewhat above atmospheric is insured at all times. No air is in contact with the oil, visual inspection of height gives an indication of oil content, it is easily filled and occupies less space than the air dome type. High internal pressures are not considered necessary either for normal operation of cable or for reimpregnation of old cable. The latter takes place slowly and does not yield very readily to acceleration by the application of pressure.

The first extensive installations of reservoirs on the system were not intended to serve as the flexible part of the cable system, allowing for change in volume with that of temperature, but rather to maintain the pressure above atmospheric throughout the cable and to supply good oil to cable that had either been poorly impregnated at the factory or that developed voids and dried out subsequently. In other words, the prime purpose was to rejuvenate old cable. About 50 miles of old (1920-22) 3-250,000-circ.-mil $\frac{17 \times 11}{64}$ paper and lead cable which had previously operated at 13 kv., was being summoned into use at 27 kv. In some cases duct limitations prevented using larger cable. For the most part, however, it was considered justifiable economically to get as much use of cable as possible (removing after failure) rather than to make a reinstallation at the start. The 135-95-kv. direct-current (conductor to conductor and conductor to ground) test, which was considered necessary to insure against the occurrence of operating failures, gave rise to a great number of test failures on a few feeders. In each case examination indicated that a lack of compound was the contributing factor. Having in mind the results of previous experiments on migration, it was decided to install reservoirs on 25 of the 120 joints of one feeder in the hope that the thin oil with which they were filled would renew the life of the old cable. The results were most gratifying.

During the next few months all failures occurred in sections remote from oil-filled joints. The experiment was complete. The feeder was then operated at 13 kv. for six months, during which time all joints were equipped. Following this testing prior to 27-kv. operation was resumed. Several failures 40 to 100 ft. from joints resulted. Oil was found 20 to 40 ft. back from joints. Finally the feeder passed the test and was put into operation. It has since—that is, for the past fourteen months—operated without any trouble. It has been out, tested and put back on the system without the usual series of failures. This behavior is to be contrasted with that previously obtained when the feeder could not be operated at 27 kv. Similar results have been secured with the feeders of the same type and on one containing old (1923—dry, with cheese formation) cable $\frac{20 \times 10}{64}$ on which the manufacturer suggested that reservoirs be installed.

The accompanying graphs indicate that quite appre-

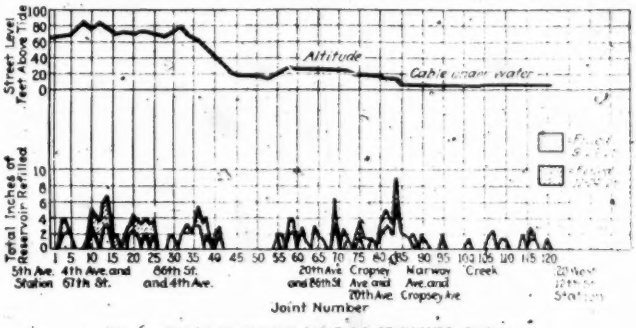


FIG. 6.—RECORD OF FILLING CABLE OIL RESERVOIRS, SHOWING EFFECT OF ALTITUDE VARIATION

ciable amounts of oil enter cable. The average per 200 ft. section is approximately ¼ qt. per six-month period. Fig. 6 shows very clearly the effect of altitude variation. By far the greatest amounts of oil enter at upper levels. To date there has been no noticeable inflow of oil to reservoirs at low points.

No provision has been made to facilitate or create a tendency for movement of air in cable toward reservoirs

or traps. With good cable, which is well saturated, this is not a matter of much concern. In the case of old cable containing air it is felt that the normal variation in the level of cable will be sufficient to provide for such movement.

Details of Installations

The first collapsible reservoirs installed on the 27-kv. system were screwed directly to joint nipples. A 15-lb. weight was used to aid collapse. This set-up very frequently necessitated reracking the cable, made it necessary to equip each joint with one bellows and, since these could not always be kept in a vertical position, gave rise to appreciable stresses in the sheath due to the eccentric forces produced. It was soon realized that some other method must be developed. Installations similar to those in Fig. 8 resulted. A bracket in an unused upper corner of a manhole supports the weighted reservoir filled with oil. Connection is then made from this to as many joints as it is felt safe to bring to a common oil source. Standard brass fittings, reducers, petcocks, etc., and ½-in. copper tubing are used in the accomplishment of this. When multiple connections are made, no two joints on feeders to the same substation are piped to a common reservoir. In all cases the tubing has been made to slope downward from the reservoir to the lowest joint in order to prevent trapping air along the line. The 30-lb. lead disk weights develop approximately ½ lb. per square inch pressure within the bellows. Due to this and the static head of oil in the pipe line the pressure within the joints is of the order of 2 lb. per square inch. This is considered ample both for rejuvenation and detection of leaks.

Failure in a joint usually develops enough pressure to "blow up" the sleeve. When this pressure is applied to a reservoir, due to the large area on which this may act, very large forces are developed. These usually expand the bellows and blow out the ends or, if such motion is opposed, may rupture the constraining parts. In addition to this, if one joint of a cascade or parallel-connected group should fail, internal pressure developed might lead to further trouble in adjacent joints. In order to prevent such action a check valve was developed for use in each joint nipple. It consists of an "alemite" fitting with the spring removed and so is nothing more than a steel ball check. This is normally open and allows slow passage of oil in and out of the joint. The slightest "sudden pressure" will, however, seal it and prevent relief at the bellows or cause damage to adjacent joints.

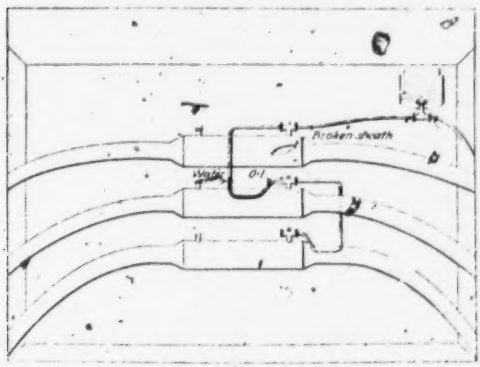


Fig. 7—Installation of reservoir for cables under water

In the more recent installations plugs are provided at the tops of the reservoirs to allow for removal of small amounts of trapped air which may be introduced when refilling through the auxiliary "alemite-fitted" opening to the reservoir system. Inspection to determine the need for such refilling or draining (the latter may eventually be necessary) will be made at intervals of four to six months.

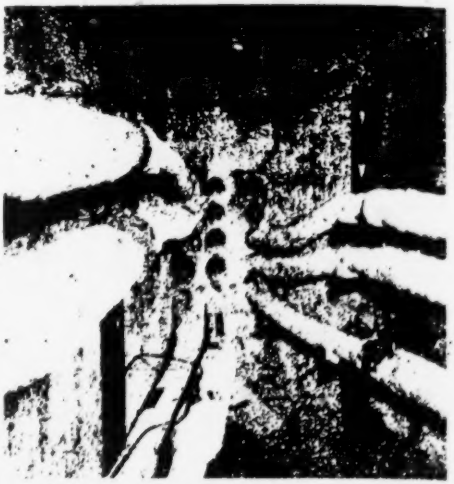


Fig. 8—Method of installing reservoir at cable manhole

The use of multiple or cascade connections of joints may be objectionable in manholes that are likely to be filled with water inasmuch as rupture of a joint sleeve at an upper level might allow water to enter the lower joints. This may be taken care of by the use of individual pipes from the joints to a common header or by putting slight loops in the tubing, as indicated in Fig. 7.

Future Installations

Authorization has been obtained to equip all of the 50 miles of 13-kv. cable operating at 27 kv. It is expected that this will gradually be extended to cover all 27-kv. cable. When installed, these oil-filled reservoirs should not only reimpregnate cable but improve joints, reduce cost of refilling and improve operating characteristics of feeders.

Three feeders to an alternating-current network are being installed at the present time. The importance of these can hardly be overestimated, hence the use of the very best cable and installation and jointing methods of the highest order. These joints will be oil filled and fitted with bellows type reservoirs. It is expected that, with the assurance of a well-saturated and filled cable and joint system under constant pressure slightly above atmospheric, very satisfactory results will be obtained. The use of fairly light compounds in the cable will facilitate transmission of pressure through the cable to the reservoirs. It may, at the same time, allow an appreciable oil flow due to static head. This will be compensated for by draining and filling the reservoir at regular intervals.

In concluding, it may be said that a system has been developed and installed that is highly satisfactory not only for reimpregnation of old cable but also for im-

proving the operating characteristics of any jointed cable systems. It is a cable user's response to manufacturers questioning pressure conditions after installation and constitutes one part of what may eventually be the continual use of reservoirs on cable from the time of completion of the leading operation.

Supervisory System Saves Transformer

By O. M. Ward
Assistant Electrical Engineer, Electric Distribution Department, Milwaukee Electric Railway & Light Company, Milwaukee, Wis.

THE value of supervisory control was demonstrated by a recent rather unusual experience on the system of the Milwaukee Electric Railway & Light Company. In this case the control system very probably saved a 10,000-kva. transformer from burning out. This experience also emphasized the potential dangers lying in oil gages that show anything but the actual oil level in the transformer.

A short distance beyond the northwest limits of the city of Milwaukee is a 132-26.4-kv. transformer bank, consisting of three single-phase, 10,000-kva. transformers and several outgoing 26.4-kv. lines. This substation is controlled from the load dispatcher's office by means of a relay-type supervisory control system. During the early morning hours one day the load dispatcher received an intermittent indication that a transformer was overheated at this substation. It is the practice to have trouble men take care of emergency switching and inspection of unattended substations, and a trouble man was dispatched to this substation, with instructions to examine the transformers. After making an inspection of the equipment the trouble man reported that the transformers were not hot. The intermittent alarm which the load dispatcher had received had ceased altogether by this time, and it was presumed that the supervisory system was in error.

A short time later, however, indication was again given of excessive transformer temperature. This time the indication was continuous. One of the regular substation maintenance men, who was then ordered out, found the thermometer of one 10,000-kva. transformer indicating approximately 75 deg. C. This is the temperature at which alarm is given.

Fortunately this occurred during a light-load period, and the transformer bank could be spared without inconvenience. Upon investigating the cause for the high temperature, it was found that the oil in this transformer was low, although the gage showed about 2½ in. of oil in the conservator tank. All of these transformers are connected through valves to an oil storage tank buried in the ground. The drain valve on this particular transformer had developed a slow leak, and approximately 14 bbl. had run into the storage tank. This lowered the oil in the transformer to a point just below the top opening of the cooling radiators, thus cutting off oil circulation. After filling the transformer to the proper level, the bank was put back in service apparently undamaged.

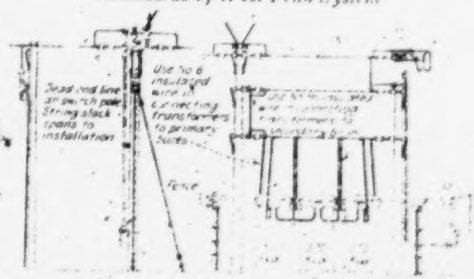
The connection between the conservator and main transformer tanks of this installation was so constructed that about 3 in. of oil in the conservator tank could not be drained into the main tank. The oil gage extends to within approximately ½ in. of the bottom of the conservator tank. This resulted in a false indication of the transformer oil level. Approximately 2½ in. has now been blanked off at the bottom of the gage. In order to guard against again losing oil, the connections in the drain pipes leading from the transformers have also been blocked off.

If this low oil condition had existed at a fully automatic substation without remote indication, the probabilities are that a burned-out transformer would have been the first alarm of unusual conditions. Even in an attended substation it is doubtful whether the operator would have discovered the trouble before serious damage resulted unless, of course, there was a high-temperature alarm in service. Feeling the transformer radiator when the oil level is low gives no indication of the transformer temperature, because there is no oil circulation through the radiators. The lower part of the main transformer tank, under these conditions, is also fairly cool. That is what fooled the trouble man who made the first inspection.

The supervisory control system for this substation has been in service about one year. Its operation has been highly satisfactory. There have been a number of instances where the 26.4-kv. lines feeding out of the substation have opened automatically due to lightning surges and other causes. The supervisory control has functioned properly in all cases. On one occasion when an intentional ground was put on a spare conductor in the control cable (the intentional ground was for test purposes), a conductor on one of the 26.4-kv. lines was accidentally grounded by the boom of a steam shovel working on the road adjacent to the line. The supervisory relays were thrown out of step and the set jammed. The load dispatcher simply had to press the "reset" button and remote operation was successfully resumed.

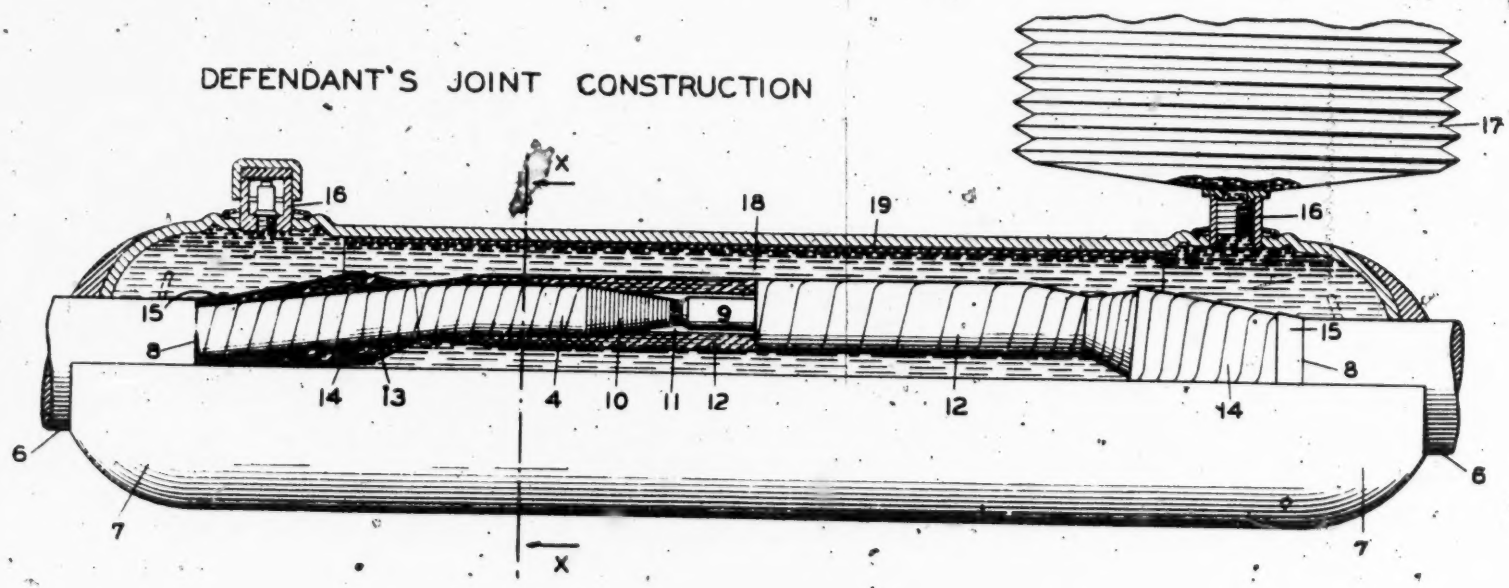
General 6,900-Volt Transformer Installation

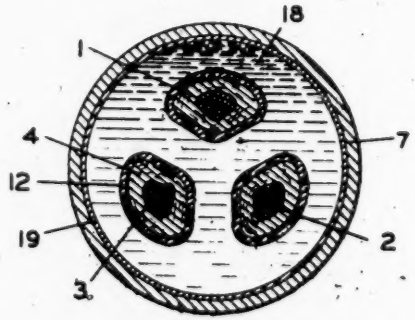
Standards of West Penn System



THE above illustration gives the relative location of various equipment when two or more transformers are necessary and is not a construction drawing. Where pole-top switch must be placed more than one span from transformer installation, the relative location of pole-top switch and lightning arresters may be interchanged. Place a strip of 2-in. copper ribbon under transformers to ground cases and connect ribbon to ground rod with No. 6 copper wire. Steps may be used below 7-ft. point when poles are within a standard transformer fence.

DEFENDANT'S JOINT CONSTRUCTION





SECTION X-X

DRAWING 'E'

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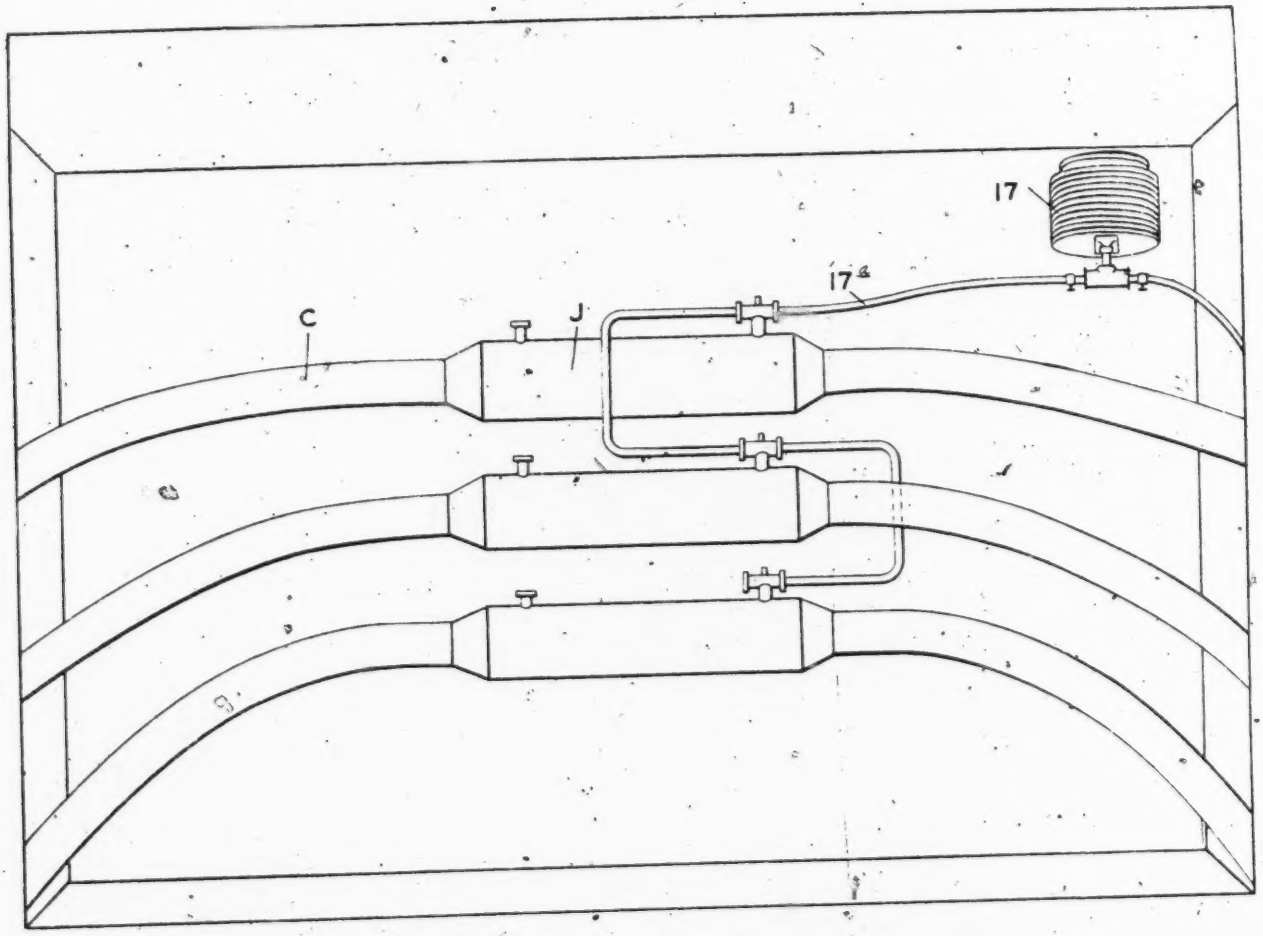

CABLES WITH COMMON OIL RESERVOIR

DRAWING F

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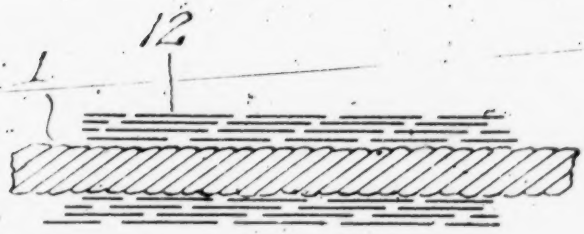
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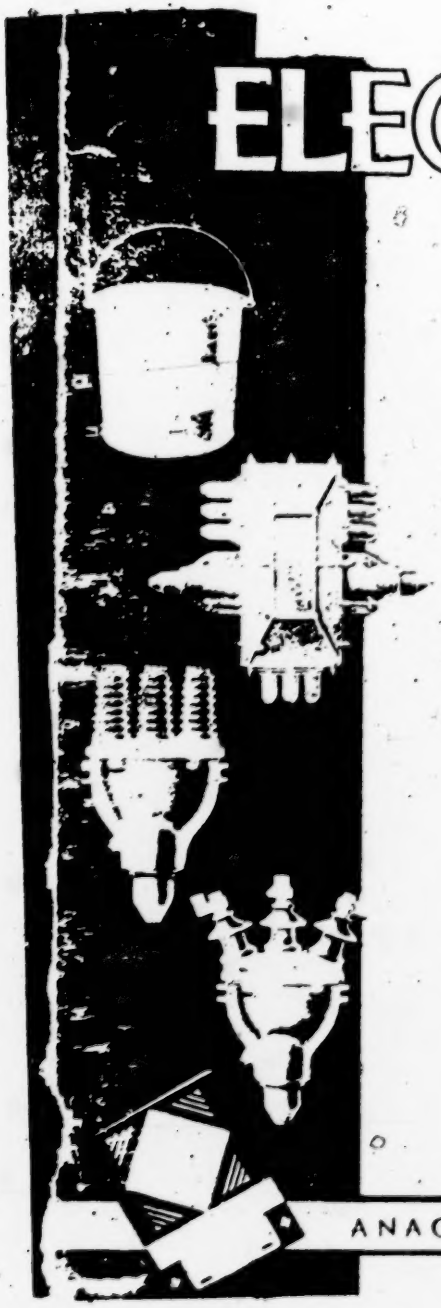

ELECTRICAL WORLD

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With the acquisition of a line of Cable Accessories, Anaconda offers a *complete* Cable Service

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Delegates on February 27 passed the Hodges-Watkins bill, amending the 1929 water power act in three major respects, by a vote of 75 to 11. The bill increases the royalty rate from 10 cents to $2 per horsepower, defines the word "project" to mean a single unit of development and inserts a new recapture clause (ELECTRICAL WORLD, February 27, page 262.) If the bill becomes law, it is freely predicted that would be developers will lose their interest in the state's hydro resources. Under the terms of another House bill originating in the committee on taxation and finance a depletion or gross sales tax of 4 per cent would be levied upon the gross proceeds of water-power companies operating in West Virginia, over and above all other royalty taxes, and the same rate is fixed as to companies furnishing electric light and power. Electric light and power companies pay three fifths of 1 per cent under existing law. The House has passed a bill requiring the Public Service Commission to use in rate cases the valuation of a public utility submitted to the state tax commissioner and an amendment to another bill relating to the commission that would provide for the election of the members of the commission and of a people's counselor.

WISCONSIN—A bitterly contested joint resolution calling for a constitutional amendment to permit Wisconsin to engage in the public utility business was adopted by the Senate February 24 and sent to the Assembly. The vote was 18 to 14. Under the terms of the resolution the question of state-owned and state-operated utilities will be put to a referendum vote. The present Assembly and the next Legislature must adopt the resolution before it goes to a referendum. The Legislature, following the referendum, must then adopt the measure before it becomes law. The state could under this measure, recapture its water power and engage generally in the light, heat and power business. State corporations could be formed which would issue unlimited obligations.

Supreme Court Dismisses Alabama Power-Tax Suit

ALABAMA'S SUIT to recover from the United States taxes alleged to be due under a state law upon hydro-electric power sold by the federal government at Muscle Shoals, plus penalties and interest because of non-payment, came to an end last week when the United States Supreme Court denied jurisdiction, thus sustaining the Court of Claims' dismissal of the suit. In its opinion the Supreme Court said:

We do not see how the claim of the state can be said to be founded upon the Constitution. If the claim is valid, which we are far from implying, it is under the state's original powers as such, and the only bearing of the Constitution is that it did not take the power away. Neither do we regard the claim as one for damages in a case not sounding in tort within the meaning of the act. There are few cases of this sort that cannot be brought under the head of a contract implied in law, and it being established that such contracts are not within the jurisdiction of the Court of Claims, we think that this phrase cannot be extended to a controversy concerning the boundary between the two sovereign powers. The claim is not technically one for damages as was the claim in assumpsit. It is a claim for a tax that the United States never has promised to pay and for a penalty. It does not fall within the act as it has been construed for many years.

Are Utilities Infringing Cable-Joint Patent?

THREE RECENT EVENTS have revived widespread interest in the United States Court of Appeals' (Sixth Circuit) decision of December 6, 1929, against the Cleveland Electric Illuminating Company for infringing the Torchio patent on cable joints (No. 1,172,322), as a result of which, it has been alleged, the company had to pay $18,000 royalty for 900 joints, or $20 a joint.

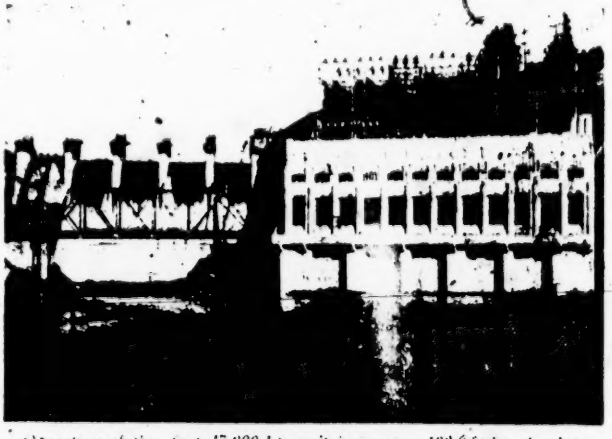
One of these events was the finding of a paper presented March 9, 1911, by C. Vermet before the (British) Institution of Electrical Engineers. This paper, published in the *Journal* of the Institution, (Vol. 47, 1911), is alleged by some engineers to cover the features patented by Torchio and to antedate his application, filed March 13, 1915.

Another event was the revelation that two engineers jointly witnessed on November 10, 1930, the digging up and testing of a cable joint alleged to embody features covered in the Torchio patent and to have been installed in 1914—before the patent application.

The third event was the offer on February 18, 1931, by a representative of the patent assignee to consider settlement on the basis of joints to be installed in the future and to waive past infringements if the proposed plan is accepted. The settlement would be based on operating voltage of joints and their number, and it could be extended over a period of years possibly two years beyond expiration of the patent, which will occur on February 22, 1933. The offer points out that the patentee would disregard the royalty rate established in the alleged settlement with the Cleveland company by a prior assignee. If utilities were licensed to apply the patent, they would not have to pay an additional royalty if they purchased joints from cable manufacturers.

The assignee making this offer through E. R. Alexander of the Cleveland Trust Company said that there was no intent to levy an unreasonable tax on the industry and that, in his view, the situation should be so handled as to avoid the expense of further litigation and to allow utilities and manufacturers to develop further possibilities of the oil-filled joint. However, if necessary, the assignee's representative asserts, the owners are prepared further to contest Torchio

BRITISH COLUMBIA'S LATEST HYDRO PLANT



Operation of this first 47,000-hp. unit in coming 188,000-hp. development at Ruskin is another step in putting the Canadian Pacific province in the ranks of great water-power producers, along with Quebec, Ontario and Manitoba

520

PLAINTIFF'S EXHIBIT No. 27

Cable Oil Splices
to 10-2-41 Aug 13, 1941

standard splices

#19 – Standolite	196 hrs.	OK	
#20 – Standolyte	154 " –	Failed in cable	3 liquid voids for length
#21 – Insuline + 10% Standolite	175 " –	OK	
#22 – Genuine	58 " –	Failed in cable	moisture between splice and end

Special large reservoir splices

#23 – Square, copper tape wrap Standolite vacuum	22 hrs –	OK	
#24 – Round 6", copper gauze wrap Standolite vacuum.	14 " –	OK	

PLAINTIFF'S EXHIBIT No. 28

U.S. District Court E.D.N.Y.
In Equity 547
Pltf Exhibit 28

Cable Oil Splices
April 21/37 to 9:30 a.m. Monday Feb. 1st

Standard Splices

#19 - Standoline — 243 lb

#21 - Insuline + 10% Standoline — 222 lb

Large Reservoir Splices

#23 - Standoline large space — copper tape shield

#24 - Standoline - 6" round — copper gauze shield

PLAINTIFF'S EXHIBIT No. 29

Def 5476 Oil Spills

April 21/37 to 8-9 in used wooden Tubing 24" 19..

#19 – 4" Standard (light oil)	Just min. pull.	244 lbs	
	Taken off till (standing pull)	200	approx
	In till 2" min drained	20 "	
	Total time in test	264	
#24 – 6 Gauge, light oil no nick	Just	65	
	drained	191	
	Total	256	
#25 – light oil drained and heavy oil (chemical solidifier)		203	
#26 – light oil upstump 10 Sec	Just	183	
	drained	19	
	Total	202	
#27 – 6" Standard + Gauge nick	Just	26	
	drained	136	
	Total	162	*
#28-5 Standard + Gauge nick	Just	50	
	drained	80	
	Total	130	

* Taken off 2 to make room for #19 retest

TEST

AT

DATE

THE NEW YORK EDISON COMPANY
TEST DEPARTMENT
DATA SHEET

TESTERS

5474

30

apl 21/30

To 8 Cm Thursday Apl 18th 9:15

				Hours
19	Standard Standard	OK		244
20	Standard	Test Cable completed (in use)		168
21	Standard + 10% Standard	OK		222
22	Standard	Test completed Cable (in use)		66
23	Copper tape shield - Standard 6" space		Duct —	28
			Manhole —	13
		OK		41
24	Copper tape shield - Standard 6" round		Duct	60
			Manhole	64
				124
25	3 Standard 18 Standard Standard pitch 2" 6" round			64
26	Standard 18 in added 6" round			64
27	James's Compound Standard 6" round		Duct	26
			Manhole	17
				43
Under (24)	Separator Standard			64

Val Hayden Rice

Die Splices & Ans Wire 1.09.6

#19 – light Cable	Duell	249 hrs	
	Heat	200	
	Drained cold	86 "	
	" HA	12 "	← failed °
		342 "	
#24 – 6' gauge, no Camp nick	Duell	65 ° hrs	
	Drained-Cold	270 "	
	" -HA	8 "	← failed
		345 "	
#25 – Stranded drained, (Red Insulation substituted)	Duell-Cold	281 hrs	
	" -HA	11 "	← failed (C)
		292 "	
#26 – Stranded + Rosin	Duell –	183 hrs	
	Drained-Cold	88 "	
	" -HA	15 "	← failed (B)
		286 "	
#28 – 6" gauge, Camp nick	Duell –	50 hrs	
	Drained-Cold	149 "	
	" HA	8 "	← failed (A)
		207 "	

(A) These Splices have been examined – with failed as follows:

between Conductors, at Edge of Connectors

(B) Examined, Rosin did not discolor, liquid

(C) " " failed in Cable 7 inches from Splice

413

525

PLAINTIFF'S EXHIBIT No. 32

THE NEW YORK EDISON COMPANY,
88 DUANE STREET.

OFFICE MEMORANDUM.

Test Department
92 Varick Street

#01775
Partial

U.S. District Court E.D.N.Y. In Equity 5434 Exhibit 32

November 27th, 1914.

Mr. P. Torchio,
Chief Electrical Engineer:

Kindly find herewith a summary of the results of the tests on high tension splices, to date (Wed., Nov. 25, 1914. 12-night).

PRELIMINARY SINGLE PHASE TESTS

(1) Edison Mica Tape Splices, Vacuum Filled; Compound

Test: One conductor against other two,
50,000 volts - 16 hours 3 minutes
75,000 " - 19 " 54 "

Examination: The conductors failed successively to the sheath. It was found that the failure occurred to the edge of the cable sheath, which projects inside of the wiped sleeve. The failures had occurred at voids in the compound, one as large as an egg. It was not quite clear, however, whether the failure was due to an abnormal distribution of stress, due to the presence of air, or whether it was merely due to the very thin layer of compound at this point. In this single phase test the sheath was at some uncertain potential with reference to the conductors, and the test is therefore not very definite.

(2) United, Hand Made Conductor Square ends, Rope Filler, Atmospheric Paraffine Filled

Test: One conductor against other two,
50,000 volts - 19 hours 15 minutes
55,000 " - 3 " 15 "

Examination: This splice failed between conductors, through the rope fillers, opposite the edges of the copper sleeves. The hand insulation was punctured in a fairly straight line. It was found that little or no paraffine had penetrated to the space between the hand wrapped conductors, and none within the hand wrapping.

REGULAR EDISON SERIES - 3-PHASE TEST - ATMOSPHERIC FILLED

(1) Hand Made Standard Square End Splice, Paraffine

Test: 30,000 volts - 41 hours 32 minutes
50,000 " - 133 " 32 " (to 12 night 11/25/14)

Still on test.

526

THE NEW YORK EDISON COMPANY,
66 DUANE STREET,

OFFICE MEMORANDUM.

Test Department
92 Vandam Street

#01775
Partial

(2) Hand Made, Paragon Taped, Tapered Approx. 1-Inch, Parafine

Test: 50,000 volts - 46 hours 20 minutes

Examination: Broke down between conductors, at a point opposite the edge of the outer belt of mill insulation. This was not in the hand worked part of the splice, but the conductors may have been slightly separated at this point. The splice was well filled with parafine.

(3) Hand Made, Impregnated Paper Tape, Tapered Approx. 1-Inch, Parafine

Test: 50,000 volts - 46 hours, 37 minutes

Examination: Broke down between conductors in the cable at a point about 3.5-inches beyond the edge of the outer belt of mill insulation. The failure was therefore not in the splice at all, and the conductors were probably not disturbed at this point, when the splice was made.

UNITED SERIES - 3-PHASE TEST - ATMOSPHERIC FILLED

(1). 250,000 c.m. Hand Made, 4-Inch, Pressed Paper Sleeve, Hydrolene Filled

Test: 50,000 volts - 5 hours 15 minutes

Examination: Failed through pressed paper sleeves between two conductors. The conductors have square-cut mill insulation, lightly-taped over the copper sleeve with linen tape, and the paper sleeve slipped over. The failure extended from the copper sleeve through the linen taping, compound, and paper sleeve, and in the same manner in the adjacent conductor. The splice was very thoroughly filled with compound, including the interior of the conductor sleeves.

(2) 250,000 Mica Sleeves, 5-Inch, Hydrolene Filled

Test: 50,000 volts - 11 hours 30 minutes

Examination: Failed between conductors at a point opposite the edge of the outer belt of mill insulation. This was not in the made up portion of the splice. The conductors were probably spread somewhat, and slightly separated, at this point, but on the other hand the whole splice was very thoroughly impregnated with compound, and compound was present in good quantity at the point of failure.

All of these samples are being preserved, and are prepared for exhibition. Sketches and measurements have also been made, to be included in a final report.

THE NEW YORK EDISON COMPANY,
55 DUANE STREET.

OFFICE MEMORANDUM.

Test Departm
92 Vandam St.

#01775
Partial.

S. G. Rhodes, Engr. M. & T. Depts.

AM:M.

Chief of Laboratory.

528 PLAINTIFF'S EXHIBIT No. 33.

THE NEW YORK EDISON COMPANY,
55 DUANE STREET.

#01775
Partial-E

OFFICE MEMORANDUM.

Test Department
92 Vandam Street

November 30, 1914.

U.S. District Court E.D.N.Y.
Entered in evidence 5-4-16
Plf. Exhibit 33
April 21/30

Mr. P. Torchio,

Chief Electrical Engineer:

Supplementing our first partial report on high tension splice tests, and bringing the record to 12-midnight, Saturday, November 28th, we have the following:

REGULAR EDISON SERIES - 3-PHASE TEST, ATMOSPHERIC FILLED

(1) Hand Made Square End Splice - Paraffine

Test - 30,000 volts - 41 hours 32 minutes
50,000 " - 148 " 45 "

Examination: Failed between conductors in the cable, at a point 10-inches from the end of splice.
It was found that oil had penetrated into this sample as far as the splice, owing to the long time during which it had been immersed. The oil had been carried in the rope filler, but had apparently some effect on the compound in the outer layers of paper.

S. G. Rhodes, Eng. M. & T. Depts.

AL:K.

Alexander Macnicol
Chief of Laboratory.

529

PLAINTIFF'S EXHIBIT No. 34

#01775
Partial-3

OFFICE MEMORANDUM.

December 2nd, 1914.

Mr. P. Torchio,

Chief Electrical Engineer;

Supplementing our previous partial report on high tension splice tests, and bringing the record up to 12-noon Wednesday, December 2nd, 1914, we have the following:

REGULAR EDISON SERIES - 3-PHASE TEST - ATMOSPHERIC FILLED

(4) Hand Made, Varnished Cambric Tape Served with Varnish

Test - 50,000 volts - 63 hours 15 minutes

Examination: Failed between conductors in cable, 5.5-inches from the end of splice.
The actual taper in this sample was about 1.5-inches.

(5) Mica Sleeves, Tapered.

Test - 50,000 volts - 53 hours 18 minutes

Examination: Failed in splice between conductors. The failure occurred around the ends of the mica sleeves, from the edges of the copper conductors. The insides of these mica sleeves were well filled with paraffine.

UNITED E.L. & P.Co. SERIES - 3-PHASE TESTS

(3) Mica Tubes, Hydrolene Atmospheric Filled. Paragon Tape Arounf Bare Copper, about half filling space within mica sleeves.

Test - 50,000 volts - 8 hours 52 minutes.

Examination: Failure between conductors, just under edge of outer belt of mill insulation.

The following splices are at present on test:

Nos. (1), (2) and (3) of the Edison vacuum series.

S. O. Rhodes, Eng. M. & T. Depts.

AM:M.

Chief of Laboratory.

PLAINTIFF'S EXHIBIT No. 35

THE NEW YORK
66 DUANE

#01775
Partial-4

OFFICE MEMORANDUM.

Test Department
92 Vandam St

December 14, 1914.

Mr. P. Torchio,

Chief Electrical Engineer:

Kindly find herewith a summary of the results of the tests on high tension splices for the period from Wednesday, December 2nd, 12 noon, to Saturday, December 12th, 1914, 12-night.

REGULAR EDISON SERIES - 3 PHASE TESTS - VACUUM FILLED

(1) Hand Made, Standard Square End Splice, Paraffine:

Test - 50,000 volts - 148 hours 24 minutes

Examination - Failed between conductors, in cable, 13-inches from end of sleeve.

(2) Hand Made, Paragon Taped, Tapered Approx. 1-Inch, Paraffine:

Test - 50,000 volts - 56 hours 33 minutes

Examination - Failed between conductors, in cable, 17-inches from end of sleeve.

(3) Hand Made, Impregnated Paper Tape, Tapered Approx. 1-Inch, Paraffine:

Test - 50,000 volts - 69 hours 40 minutes

Examination - Failed between conductors, in cable, 8-inches from end of sleeve.

(4) Hand Made, Varnished Cambric Tape Served with Varnish, Paraffine:

Test - 50,000 volts - 82 hours 44 minutes

Examination - Failed between conductors, in mill insulation, 1-inch from edge of mill outer belt, and under edge of sheath projecting within the sleeve.

(5) Mica Sleeves, Tapered; Paraffine:

Test - 50,000 volts - 73 hours 58 minutes

Examination - Failed between conductors, in cable, 11-18 inches from end of sleeve. Conductor mill insulation badly wrinkled.

THE NEW YORK EDISON COMPANY,
55 DUANE STREET.

#01775
Partial-4

OFFICE MEMORANDUM.

Test Department
92 Vandam St

UNITED E.L. & P. CO. SERIES - 3 PHASE TESTS

(4) Micanite Separators, 8" Long, Hydrolene Pressure Filled:

Test - 50,000 volts - 7 hours 59 minutes

Examination - Not yet examined.

SUPPLEMENTARY EDISON SERIES - 3 PHASE TESTS

(Test #12) Mica Tubes 7", Safety #17 Compound, Vacuum Filled:

Test - 50,000 volts - 47 hours 25 minutes

Examination - Not yet examined.

(Test #13) Mica Tubes 5" — Compound, Vacuum Filled:

Test - 50,000 volts - 43 hours 24 minutes

Examination - Not Yet examined.

(Test #14) Mica Tubes 4", "Hollowax" Compound, Vacuum Filled:

Test - 50,000 volts - 0 Hours, 3 minutes (Approx)

Examination - Failed in splice, around mica conductor sleeves, examination not completed.

There are at present on test

(5) United E.L. & P. Co., Micanite Separators, Paraffine Filled.

(Test #15) Supplementary Edison Series, Hand Made, Paper Taped, "Hollowax" Compound, Vacuum Filled.

These two splices have been on test 12 hours to date.

S. G. Rhodes, Eng. M. & T. Depts.

AM:M

Chief of Laboratory.

THE NEW YO
55 DUANE STREET,

OFFICE MEMORANDUM.

Test Department
92 Vandam St

#01775
Partial-5

December 14, 1914.

Mr. P. Torchio,

Chief Electrical Engineer:

Please find herewith a preliminary analysis of the tests on high tension cable splices, based on the results reported up to our memorandum partial report No. 4, to 12-night, Dec. 12th, 1914. Since all of these tests have been uniform, namely: 50,000 volts, 3 phase, between conductors until breakdown, the analysis is based on the duration of the test for the various samples.

(A) The test results to be analyzed are as follows:

No.	Sample		Failure	Hours
1	Reg. Edison Series, Atmospheric	#1	Cable	148.75 + **
2	"	2	Splice, mill insu.*	46.33
3	"	3	Cable	56.62
4	"	4	Cable	63.25
5	"	5	Splice	53.18
6	Reg. Edison Series, Vacuum	#1	Cable	148.40
7	"	2	Cable	56.55
8	"	3	Cable	69.67
9	"	4	Splice, mill insul.*	82.73
10	"	5	Cable	73.97
11	Edison Supplementary Series	#14	Splice	0.05
12	United	#1	Splice	5.25
13	United	2	Splice, mill insul.*	11.50
14	United	3	Splice, mill insul.*	8.87

*Failure in mill insulation under splice sleeve, generally near where conductors emerge from mill belt insulation.

**Preceeded by 41.55 hours at 30,000 volts.

A first analysis of the above gives:

Total Number of Tests	= 14	= 100	per cent.
Failed in Cable	= 7	= 50	"
Failed in Mill Insulation in Splice	= 4	= 29	"
Failed in Splice	= 3	= 21	"

That is, 80 per cent. of all the failures were in mill insulation, of which 50 per cent. (of the total) were fairly in the undisturbed parts of the cable; only 20 per cent. of the failures were actually in the hand wrought parts of the splices.

THE NEW YORK EDISON COMPANY,
55 DUANE STREET.

#01775
Partial-5

OFFICE MEMORANDUM.

Test Department
92 Vandam St.

(B) Analysis of Failures in Cable

The following samples failed fairly in the undisturbed parts of the cable:

No.	Hours at 50,000 volts	Remarks
1	148.75	Atmospheric
3	56.62	
4	63.25	
6	148.40	Vacuum
7	56.55	
8	69.67	
10	73.97	

Summarized:	Max.	Min.	Avg.
Total (7 Tests)	148.75	56.55	88.17
Excluding the 2 high tests	73.97	56.55	64.01

The two high tests are the Edison standard splices with square ends, rope filled. We have not determined why this type of splice should influence the test of the undisturbed portions of the cable; this performance is more remarkable, because, on account of the long immersion, the tank oil had penetrated through the cable, nearly to the splice itself.

It will be seen that, excluding these two tests, the performance of the cable is quite consistent for 5 samples. The average, 64 hours, may provide a fair criterion for estimating the quality of the splices. That is, if the splices survive as long as this, they may be considered as good as the cable. If they survive longer (a test which is obtainable due to the chance of the cable being stronger than average) they may be considered better than the average cable.

It should be noted, however, that these cable failures are apparently connected with the wrinkling of the conductor mill insulation; this question is being studied along other lines, and will be reported separately. The point here is, that this difficulty will no doubt be overcome ultimately, so that

THE NEW YORK E. SON COMPANY,
56 DUANE STREET.

#01775
Partial-5

OFFICE MEMORANDUM.

the final cable product will be better than indicated by these tests.

(C) Analysis of Failures of Mill Insulation in Splices

The following samples failed through mill conductor insulation, but within the extreme limits of the splice sleeve. The failures generally occurred near the edge of the mill outer belt insulation, suggesting either mechanical injury due to the stripping of the outer belt, or an abnormal distribution of stress due to the spread, which starts at this point. Neither of these hypotheses have been confirmed in the four samples. No evidence was found to support the first, while the second is certainly not the sole cause, as some of the faults occurred too far within the outer belt (even under the edge of the lead sleeve which projects within the wipe) to have been due to spreading.

The tests were as follows:

No.	Hours at 50,000 Volts	Remarks
2	46.33	Edison Atmospheric
9	82.73	Edison Vacuum
13	11.50	United
14	8.87	United

It will be seen that the two Edison cases compare, in a measure, with the cable failures. The two United cases survived for only a short time.

(D) Analysis of Failures in Splices

The following samples failed fairly in the hand-wrought portions of the splices:

No.	Hours at 50,000 Volts	Remarks
5	53.18	Edison, Mica Sleeves, Paraffine Atmospheric
11	0.05	Edison, Mica Sleeves, "Hollowax" Vacuum
12	5.25	United, Pressed Paper Sleeves, Hydrolene.

THE NEW YORK EDISON COMPANY,
86 DUANE STREET.

#01775
Partial-5

OFFICE MEMORANDUM.

All of these are insulating sleeve splices; the two Edison samples were tapered. The United sample punctured through the walls of two pressed paper sleeves, the Edison samples both failed around the edges of the mica sleeves.

(E) Influence of Vacuum Filling

The most direct comparison between the atmospheric and the vacuum methods is afforded by the totals for the two Edison series. These are as follows:

	Atmospheric	Vacuum
Number of Cases	5	5
Failures in Cable	3	4
Failures in Splices	2	1
Actual Failure of Splice	1	0

The only comparable case for a particular type of splice is that for the mica tubes, No. 5 in each series. Here the atmospheric splice failed in 53 hours, while the vacuum splice survived the cable, which failed in 74 hours.

It is difficult to see how the vacuum filling could influence the cable itself, but for what the comparison is worth, it will be seen that, excluding the two 148 hour cases (where the comparison is favorable to the atmospheric, on account of the additional 30,000 volt test) it is as follows:

	Atmospheric	Vacuum
Minimum Nos. 3 and 7	57 Hours	57 Hours
Maximum Nos. 4 " 10	63 "	74 "
Avg. (of 2 & 3 cases respectively)	60 "	67 "

Further, under (C) it will be seen that for the two Edison cases where mill insulation failed within splice sleeves, the atmospheric sample survived for 46 hours, and the vacuum sample survived for 83 hours.

(F) Analysis of Various Types of Splices

We are not yet prepared to report fully on this subject, on account of the very close study which must be made of the failed splices. In general,

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THE NEW YORK EDISON COMPANY,
65 DUANE STREET,

#01775
Partial-5

OFFICE MEMORANDUM.

Test Department
92 Vandam St

however, it will be seen that the best performance to date has been that of the standard square end splices. Also the worst performance has been that of the mica sleeves. We do not believe that this should be taken as conclusive, however, until the exact causes of failure have been determined in each case.

S. G. Rhodes, Eng. M. & T. Depts.

Chief of Laboratory.

AM:M.

425

PLAINTIFF'S EXHIBIT No. 37

537

THE NEW

OFFICE MEMORANDUM.

Test Department
92 Vandam St

#61778
Partial-6

December 22, 1914.

Mr. P. Torchio,
Chief Electrical Engineer;

Please find herewith a summary of the results of the tests on high tension splices, supplementing our partial report No. 4, and bringing the record to Saturday, December 19, 1914, 12-midnight.

SUPPLEMENTARY EDISON SERIES - 3 PHASE TESTS

The following were reported failed in Report Partial No. 4, but at that time had not been examined. They are repeated herewith:

(Test #12) Mica Tubes 7"-Safety #17 Compound, Vacuum Filled

Test - 40000 volts - 47 hours 25 minutes

Examination - Failed in splice, between conductors, 2.75-inch from edge of mill outer belt insulation, and 3.5-inch from edge of outer mica sleeve. The point of failure was apparently through compound. A large void existed immediately over the conductors affected, extending from the inner wall of the lead sleeve to the conductors.

(Test #13)-Mica Tubes 5"-Safety #17 Compound, Vacuum Filled

Test - 50000 volts - 43 hours 24 minutes

Examination - Failed between conductors in the cable 9-inches beyond the end of the splice.

(Test #14) - Reported in Detail in Partial Report No. 4

(Test #15) - Hand Made, Tapered, Rope Filler, "Hollowax" Vacuum Filled

Test - 50000 volts - 33 hours 0 Minutes

Examination. - Failed in splice between conductors. The failure was through mill conductor insulation under the hand conductor dropping, thence between the mill and hand insulation to the edge of the hand insulation, to the other conductor.

UNITED E.L.&P.CO. SERIES - 3 PHASE TESTS

The following was reported failed in Report Partial No. 4, but at that time had not been examined. It is repeated herewith.

THE NEW YORK F IBON COMPANY,
65 DUANE STREET,

#01775
Partial-6

OFFICE MEMORANDUM.

Test Department
22 Cardiff St.

(4) Micanite Separators, 8" Long, Hydrolene Pressure Filled

Test - 50000 volts - 7 hours 59 minutes

Examination - Failed between conductors, in mill insulation about 1-inch inside of edge of mill outer belt.

(5) Micanite Separators 8" Long, Paraffine Filled

Test - 50000 volts - 25 hours 28 minutes

Examination - Failed between conductors in the cable 3" from edge of mill outer belt insulation.

(6) Specially Shaped Mica Conductor Separators, No Tape, Hydrolene Filled

Test - 50000 volts - 16 hours 7 minutes

Examination - Failed between conductors in splice, 2-inches inside of edge of mill outer belt insulation.

(7) Specially Shaped Mica Conductor Separators, No Tape, Hydrolene Filled 2.5-inches of Mill Outer Belt Insulation within the Splice

Test - 50000 volts - 11 hours 27 minutes.

Examination - Failed between conductors in splice, 0.75-inch inside of edge of mill outer belt insulation, the conductors were spread slightly at this point. The point of failure had apparently been covered with compound, but a small void was found adjacent to the failure.

(8) Similar to #7, but Compound poured at 350°F., which is lower than the previous cases

Test - 50000 volts - 31 hours 30 minutes

Examination - Failed between conductors in splice, but in mill insulation.

On Monday morning December 21st, there were on test:

2 - United splices, descriptions not yet received.

S. G. Rhodes, Eng. T& Dept.

Alexander Maurer
Chief of Laboratory.

AM:H.

427

PLAINTIFF'S EXHIBIT No. 38

539

THE NEW YOR
55 DUANE STREET,

OFFICE MEMORANDUM.

Test Department
92 Vandam St

#01775
Partial-7

January 11th, 1915.

Mr. P. Torchio,
Chief Electrical Engineer:

Please find herewith a summary of the results of the tests on high tension splices, supplementing our partial report No. 6, and bringing the record to Saturday, January 9th, 1915, midnight.

SUPPLEMENTARY EDISON SERIES - 3 PHASE TESTS

(Test No. 16)* Hand Made Standard Square End Splice, Paraffine Atmospheric Filled.

Test: 50,000 volts - 43 hours 40 minutes

Examination: Failed in splice, through mill conductor insulation just under outer belt mill insulation.

(Test No. 17)* Hand Made Standard Square End Splice, Paraffine Vacuum Filled

Test: 50,000 volts - 80 hours 49 minutes

Examination: Failed between conductors, in cable, approximately 13-inches from end of splice.

(Test No. 18) Special Paragon Tape Splice, Copper Connectors with Rounded Edges, Tapered Ends, 20/32" Paragon Tape over each Conductor, no Outer Belt, Paraffine Atmospheric Filled (Made up from 350 000 c.m., 8.5-4/32" Cable

Test: 50,000 volts - 0 hour 13 minutes

Examination: Failed in center of splice, through hand insulation, conductor to sheath to conductor.

*Nos. 16 and 17 were tested to check No. 1 Atmospheric and No. 1 Vacuum, of the regular Edison Series, both of which survived for approximately 150 hours.

UNITED E. L. & P. CO. SERIES - 3 PHASE TESTS

(9) Specially Shaped Conductors, 8" Mica Separator, 8" Mica Outer Tube, Copper Sleeves, Sector Shaped, Filled with Hydrolene at 350° F., Made up from 350 000 c.m., 7-7/32" Cable

Test: 50,000 volts - 23 hours 40 minutes

Examination: Failed in splice through mill insulation. Fault extended from edge of mica separator along surface of conductor insuletion to a point on second conductor 0.5-inch from edge of mill outer belt insulation. The mill conductor insulation badly wrinkled.

540

THE NEW YORK EDISON COMPANY,
65 DUANE STREET,

#01775
Partial-7

OFFICE MEMORANDUM.

Test Department
92 Vandam St

(10) Same as (9) but with 1.75-inches of Mill Outer Belt Insulation within the Splice, and Filled with G.E. 229 Compound at 350° F., Made up from 350 000 c.m., 8.5-4/32" Cable

Test: 50,000 volts - 133 hours 20 minutes

Examination: Failed in splice, through conductor mill insulation 2.5-inches from edge of outer belt mill insulation and 2.25-inches from edge of mica separator.

(11) Same as (9) but made up from 350 000 c.m., 7-7/32" Cable

Test: 50,000 volts - 23 hours 43 minutes

Examination: Failed in splice through conductor mill insulation, 2.75-in. from edge of outer belt mill insulation.

(12) Same as (9) but with 3-inches of Mill Outer Belt Insulation within the Splice and Hydrolene filled at 400° F., Made up from 350 000 c.m., 8.5-4/32" Cable

Test: 50,000 volts - 28 hours 50 minutes

Examination: Failed in splice through conductor mill insulation. Fault started at a point inside of mica separator 2.25-inches from edge of copper sleeve and extended back along conductor to the second conductor at a point 1.25-inches from edge of outer belt mill insulation.

(13) Specially Shaped 8-Inch Mica Conductor Separators, 8-Inch Mica Outer Tube, Hydrolene Filled at 380°F., Lead Sleeve 4.5-Inch Diameter (others 5") 3.25-Inches of Mill Outer Belt Insulation within Splice, Round Connectors Made up of 350 000 c.m., 8.5-4/32" Cable

Test: 50,000 volts - 26 hours 24 minutes

Examination: Failed in splice through mill insulation. Fault started at edge of mica separators 3-inches from edge of copper sleeve, and extended back along conductor to the second conductor at a point 0.5-inch from edge of outer mill belt.

(14) Specially Shaped 8-Inch Mica Separators, and 8-Inch Outer Tube made up from Extra Heavy Mica, Round Copper Connectors, Outer Mill Belt 1-Inch Inside of Splice, Hydrolene filled at 380°F. (Made of of 350 000 c.m., 8.5-4/32" Cable

Test: 50,000 volts - 53 hours 54 minutes

Examination: Not yet completed.

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55 DUANE STREET,

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Partial-7

OFFICE MEMORANDUM.

SAFETY I. W. & C. CO. - 3 PHASE TESTS

Three splices submitted by the Safety Insulated Wire and Cable Co., were tested with the following results. The numbers are those assigned at the factory.

(1) Hand Insulated, Tapered 3.25-Inches, 2.5-Inches Copper Connectors, 4-Inch Lead Sleeve, Safety Compound, Vacuum Filled (Made up from 350 000 c.m., 8.5-4/32" Cable

Test: 50,000 volts - 30 hours 14 minutes

Examination: Failed in splice, through hand insulation at connectors. The hand conductor insulation was 6/32-Inch thick. The hand outer belt insulation was 4/32-inch thick.

(2) Composite, Hand and Tube Insulation, Same as No. 1, except that Outer Belt Hand Insulation was Replaced by a Paper Tube in Three Sections, each 4.5-Inchs Long

Test: 50,000 volts - 28 hours 58 minutes

Examination: Failed in splice between conductors, through hand insulation opposite edges of connectors.

(3) Composite, same as No. 2, except that Paper Tubes were Hand Wrapped Paper Tape to Fill the Sleeve

Test: 50,000 volts - 27 hours 43 minutes

Examination: Failed in splice, through conductor mill insulation just under edge of outer belt mill insulation.

S. G. Rhodes, Eng. M. & T. Depts.

Alexander Maxwell

AM:M. Chief of Laboratory.

PLAINTIFF'S EXHIBIT No. 39

THE NEW YORK EDISON COMPANY,
55 DUANE STREET,

OFFICE MEMORANDUM.

Test Department
92 Vandam St

#01775
Partial-8

March 29th, 1915.

Mr. P. Torchio,

Chief Electrical Engineer:

Please find herewith a summary of the tests made on splices filled with cable oil compounds. The detailed items are grouped according to the particular property under investigation in each case. All tests were at 5C,CCC volts, 3 phase, 60 cycles. The splices were tested under various conditions, full of compound, and drained, at room temperature and at approximately 70° C. In a few cases splices were taken off test for some time and later put on test again; all of these conditions are noted for the individual items.

EDISON OIL SPLICES

Group 1 - Nos. 19 to 22 inclusive:- These first four oil splices were made up with four grades of cable compound, as follows:

Lightest Compound - "No. 1 Filler" also called "Stanoline"

Medium " - The standard compound used for cable impregnation, also called "Stanolyte"

Heavy " - Refined, de-hydrated rosin, also called "Insuline"

Special Heavy " - "Insuline" 90% and 10% of the lightest compound "Stanoline"; mixed at Safety Works.

These four splices were of the same construction. They were made from 350,000 c.m., sector 7-7/32-insulation cable, with connectors rounded at the edges to a radius approximately equal to the thickness of the connector. The splices were of standard construction, 4-inches in diameter, with the conductor and insulation square-ended. All were vacuum filled, the compound being poured at about 230° F.

No. 19 - Lightest Compound "Stanoline"

Full, room temperature	-	2[illegible]4 hrs. 2 min.
Off test	-	(200 ")
Drained, room temperature	-	[illegible] " 12 "
Drained, 70° C.	-	20 " 14 "
Total time on test	-	342 " [illegible] "

Filled in splice, between conductors, at edges of connectors.

No. 20 - Medium Compound "Stanolyte"

THE NEW YORK EDISON COMPANY,
55 DUANE STREET.

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Full, room temperature - 154 hrs. 11 min.

Failed in cable, 6-inches beyond end of splice.

No. 21 - Special Heavy Compound "Insuline" 90%, "Stanoline" 10%

Full, room temperature - 222 hrs 29 min.

Taken off test while still in good condition

No. 22 - Heavy Compound "Insuline"

Full, room temperature - 58 hrs 16 min.

Failed in cable, 3-inches beyond end of splice

Group II - Experiments to insure the retention of compound in the splice chamber, Nos. 23 to 26 inclusive

The splices in this group were made with the idea of insuring that compound would be retained in the splice chamber. In all four splices large 6-inch sleeves were used, and the sleeve was not concentric with the cable, being displaced in order to provide a reservoir having a higher level than the cable. In two of the splices means were provided to secure heavy, non-fluid compounds. Ground shields were used except in the cases of the two heavy compound splices.

These splices were made from 350,000 c.m., sector, 8.5-4/32 insulation cable, with 2-inch connectors tapered 0.8-inch to about 0.08-inch. The splices were of standard construction with conductor mill insulation tapered 1-inch. The sleeves were 6-inches in diameter.

No. 23 - Sleeve formed square, lightest compound "Stanoline" atmospheric filled. Ground shield of 0.001-inch copper ribbon

Full, room temperature	-	74 hrs.	12 min.
Drained, " "	-	16 "	33 "
Refilled " "	-	12 "	0 "
Refilled, 70° C.	-	5 "	14 "
TOTAL time on test	-	107 "	59 "

Failed in splice, between conductors, at edges of connectors.

No. 24 - Lightest compound "Stanoline" vacuum filled. Ground shield of 100 mesh copper gauze

Full, room temperature	-	65 hrs	27 min.
Drained, " "	-	274 "	32 "
Drained, 70° C.	-	5 "	0 "
TOTAL time on test	-	344 "	59 "

Failed in splice, between conductors, at edges of connectors.

THE NEW YORK EDISON COMPANY,
55 DUANE STREET,

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No. 25 - Made up with lightest compound "Stanoline" which was drained after 1 hour, when heavy compound "Insuline" was substituted-No ground shield

Full, room temperature	-	281 hrs	43 min.
Full, 70° C.	-	10 "	20 "
TOTAL time on test	-	292 "	3 "

Failed in cable, 7-inches beyond splice

No. 26 - Lightest compound "Stanoline" with lumps of commercial rosin added - No ground shield

Full, room temperature	-	182 hrs	50 min.
Drained, " "	-	86 "	14 "
Drained, 70° C.	-	16 "	27 "
TOTAL time on test	-	285 "	31 "

Failed between conductors, in mill insulation, 1.25-inch beyond edge of mill outer belt insulation, and directly under edge of lead sheath projecting within the wipe.

Note:- A comparatively small amount of compound was drawn from this splice at the time of draining, the lump rosin, of course, remained. Upon examination, after failure, it was found that the lump rosin had not dissolved to a noticeable extent.

Group III - Lamp Wick Wrapping Outside of Ground Shield

The distinguishing characteristic of these splices is the use of a lamp wick wrapping outside of the ground shield, in order to insure that the wrappings up to the ground shield will be thoroughly filled with compound, even if the splice chamber is drained. This lamp wick is used in all splices in this group, Nos. 27 to 30 inclusive, and also in all later splices down to No. 36.

These splices were made from 350,000 c.m., sector, 8.5-4/32 insulation cable, with 2-inch connectors tapered 0.5-inch to about 0.03-inch. The splices were of standard construction with conductor mill insulation tapered 1-inch. All were vacuum filled with the lightest compound "Stanoline".

Except where otherwise noted (No. 27) the sleeves were 5-inches diameter, centered - ground shields were of 100 mesh copper gauze.

No. 27 - (6-inch sleeve off-center)

Full, room temperature	-	25 hrs	32 min.
Drained, " "	-	136 "	33 "
Refilled, " "	-	12 "	0 "
Refilled, 70° C.	-	7 "	11 "
TOTAL time on test	-	181 "	16 "

Failed between conductors, in mill insulation, 1.25-inch beyond edge of mill outer belt insulation, and directly under edge of lead sheath projecting within the wipe.

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55 DUANE STREET,

#01775
Partial-8

OFFICE MEMORANDUM.

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No. 28 -

Full, room temperature	-	50 hrs	0 min.
Drained, " "	-	148 "	26 "
Drained, 70° C.	-	8 "	38 "
TOTAL time on test	-	207 "	4 "

Failed in splice, between conductors, at edges of connectors.

No. 29 -

Note:- This splice was made "carelessly", that is, an attempt was made to imitate the more common faults of workmanship, which might be expected in practice.

Full, room temperature	-	99 hrs	9 min.
Full, 70° C.	-	6 "	35 "
TOTAL time on test	-	105 "	44 "

Failed in splice, between conductors, at connectors.

No. 30 - 5-foot lengths of cable each side of splice, bent 90° from axis of splice

This splice was filled with the lightest compound "Stanoline" drained, and refilled with heavy compound "Insuline"

Full, room temperature	-	0 hrs	52 min.
Full, 70° C.	-	9 "	14 "
TOTAL time on test	-	10 "	6 "

Failed in splice, between conductors, at connectors.

Group IV - Miscellaneous Experimental Splices

All of these splices, Nos. 31 to 36 inclusive, were made up from 350,000 cm., sector, 8.5-4/32 insulation cable with 2-inch connectors tapered 0.5-inch to about 0.03-inch. The conductor mill insulation was tapered 1-inch; 5-inch centered sleeves were used; the ground shields were made from #30 mesh copper gauze. The various types were made in pairs, one with the standard straight 3-foot lengths of cable each side of the splice, and one with 5-foot lengths each side of the splice, bent 90° from the splice axis.

A - Mineral Oil Splices

These splices were vacuum filled with a safety I.W. & C. Co. compound consisting of 60% mineral oil and 40% refined rosin; poured at 250° F.

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THE NEW YORK EL. SON COMPANY,
55 DUANE STREET.

C1775
Partial-8

OFFICE MEMORANDUM.

No. 31 - Short Straight legs

Full, 70° C. - 11 Hrs 15 Min.

Failed in mill insulation, between conductors, 2-inches beyond edge of outer belt mill insulation.

No. 32 - Long Bent Legs

Full, 70° C. - 28 hrs 35 min.

Failed in splice, between conductors, at connectors.

Note:- It was observed that this compound had an unusually high co-efficient of expansion. A special test of the compound showed a 0.1 per cent increase of volume for 1°C. increase of temperature.

B - MUSLIN TAPE SPLICES

These splices were made up with 1.25-inch unbleached bias muslin tape, instead of paper tape. The splices were vacuum filled with the lightest rosin oil compound "Stanoline"

No. 33 - Short Straight Legs

Full, 70° C. - 2 hrs 58 min

Failed in splice, between conductors, at connectors.

No. 34 - Long Bent Legs

Full, 70° C. - 0 Hrs 10 Min

Failed in splice, between conductors, at edges of connectors.

C - FLUSH CONDUCTORS

These splices were made up without connectors, the conductors were butted and partially lapped, and soldered; this resulted in a somewhat uneven contour at the joint, but the sharp change in diameter due to the connector was eliminated. The splices were vacuum filled with the lightest rosin oil compound "Stanoline"

No. 35 - Short Straight Legs

Full, 70° C. - 5 hrs 25 min.

Failed in mill insulation, between conductors, under edge of mill outer belt insulation.

No. 36 - Long Bent Legs

Full, 70° C - 4 hrs 39 min.

THE NEW YORK EDISON COMPANY,
55 DUANE STREET.

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OFFICE MEMORANDUM.

Failed in millinsulation, between conductors, under edge of outer belt insulation.

UNITED E. L. & P. CO. SPLICES

No. 21 -

Made up from 350,000 c.m., sector, 8.5-4/32-inch insulation cable, with round 2-inch connectors; 5-inch round centered sleeve. The insulation consists of specially shaped micanite separators, surrounded by a micanite tube. The splice was atmospheric filled with the lightest rosin oil compound "Stanoline".

Full, room temperature	-	71 hrs 33 min.
Drained, " "	-	0 " 10 "

Failure by discharges or surface leakage; did not puncture separators nor arc around.

Note:- United splices Nos. 22 and 23 were taken off test in good condition after 132 hours and 98 hours respectively at room temperature and filled. They were removed to make space for the temperature tests; they have recently been returned to test and will be reported later.

This memorandum report is to 12 noon, Saturday, March 27, 1915.

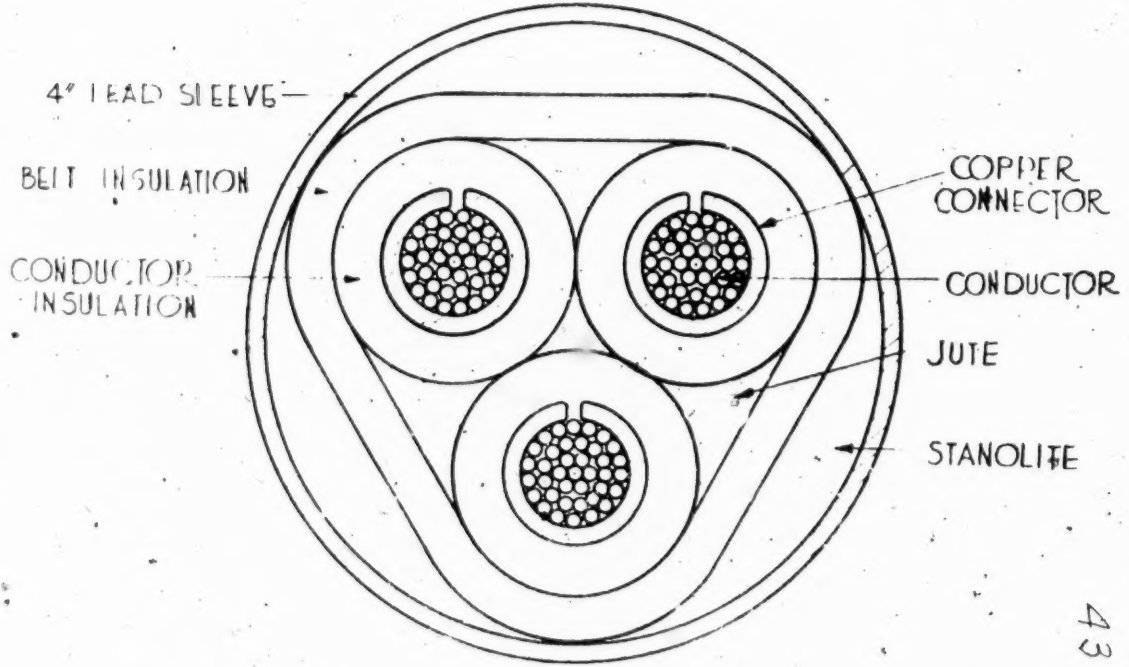
S. G. Rhodes, Engr. L. & T. Depts.,

Alexander Maxwell
Chief of Laboratory.

M.M.

59/6

NO. 20



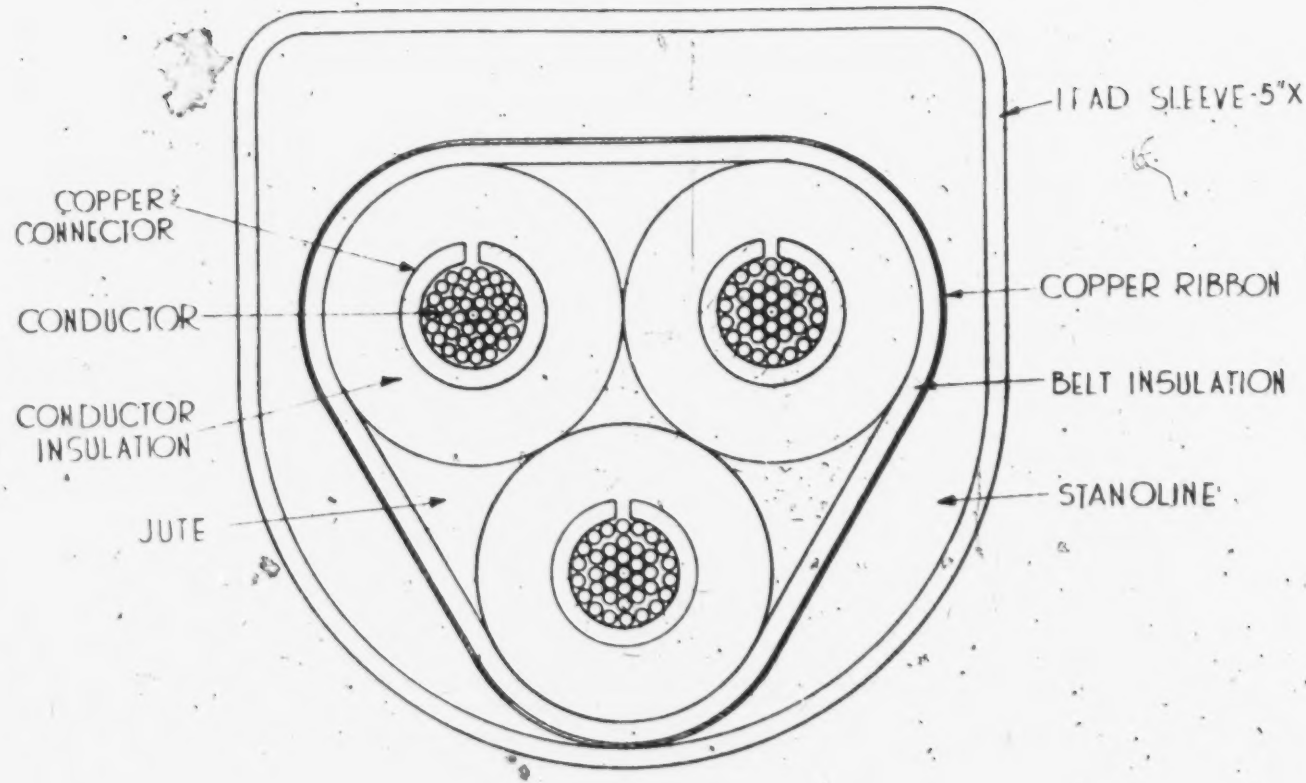
548

PLAINTIFF'S EXHIBIT No. 40

43

426

NO. 23

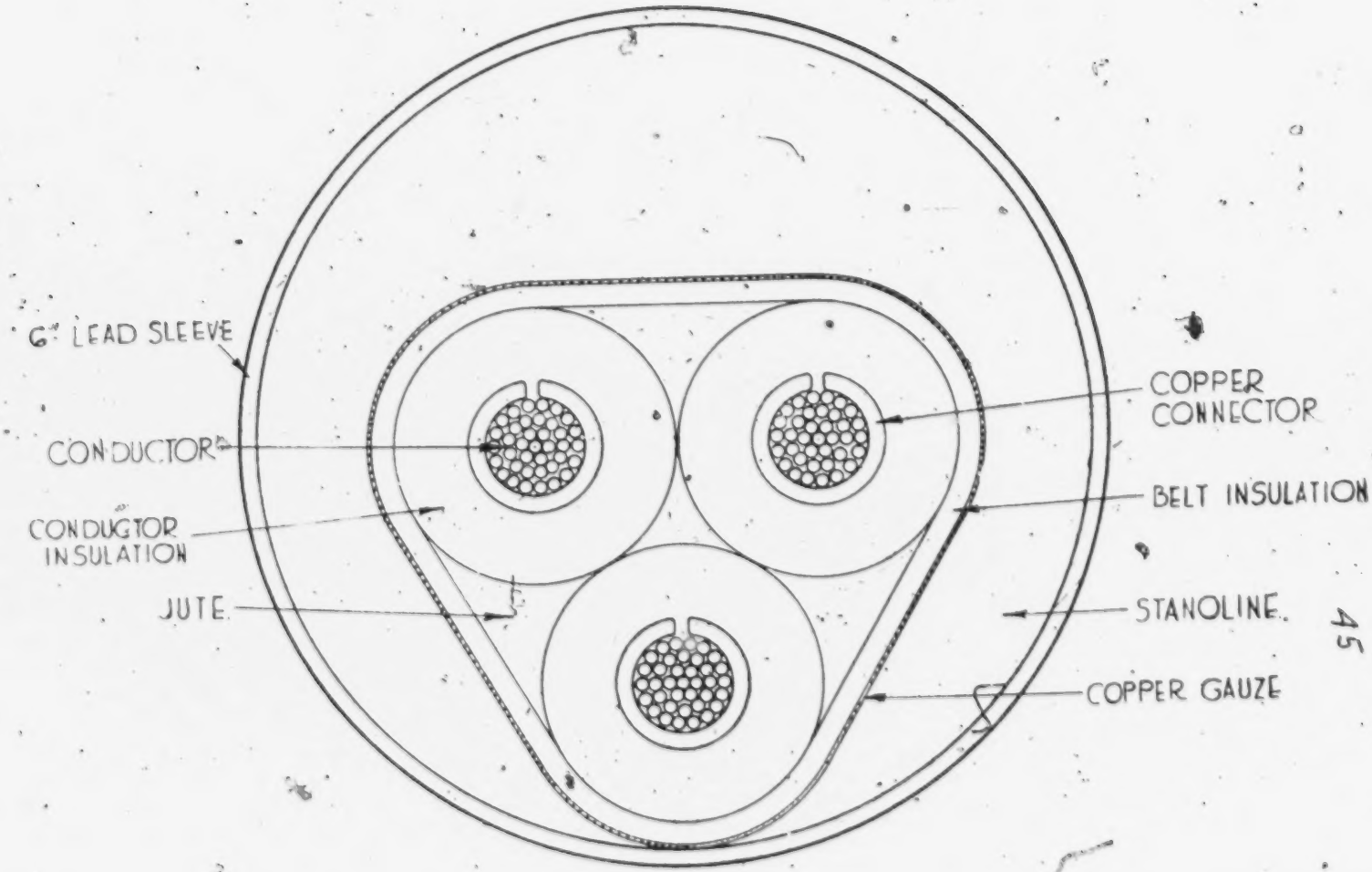


'PLAINTIFF'S EXHIBIT No. 41

549

44

NO. 24.



PLAINTIFF'S EXHIBIT No. 42

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[fol. 551] PLAINTIFF'S EXHIBIT No. 43

February 13th, 1915.

Mr. A. Rabe, General Foreman.

DEAR SIR: The following splices have been made for test at Van Dam St.:

Splice #19

Made and filled by M. Nelson, 7-32nds.—7-32nds. 3 x 350 cable. 4 x 18 inch lead sleeve. 350 sq. end connectors. Mill conductor insulation sq. ended. Gap between mill insulation and end of connector ⅛ inch. Gaps filled with rope which had been soaked for ten minutes in stanolene at 270° F. conductors insulated with six (6) mill paper, to the height of 350 gauge, each layer being treated with stanolene (1 thinner). Jacket six (6) mill paper applied to the height of 350 gauge, each layer being treated with stanolene, (#1 thinner). This splice was filled with stanolene (#1 thinner) at 27 inch vacuum. Filler prepared by being dehydrated at 270° F. for twenty (20) minutes, and then reduced by radiation at 230° F. and poured at that temperature.

Splice #20

Made and filled by M. Nelson 7-32nds.—7-32nds. 3 x 350 cable, 4 x 18 inch lead sleeve, 350 sq. end connectors. Mill conductor insulation sq. ended. Gap between mill insulation and end of connector ⅛ inch. Gaps filled with rope [fol. 552] which had been soaked for ten minutes in stanolene at 270° F. Conductors insulated with six (6) mill paper, to the height of 350 gauge, each layer being treated with stanolene (#1 thinner). Jacket six (6) mill paper applied to the height of 350 gauge, each layer being treated with stanolene (#1 thinner). This splice was filled with stanolite at 27 inch vacuum. Filler prepared by being dehydrated at 270° F. for twenty (20) minutes, and then reduced by radiation at 230° F. and poured at that temperature.

Splice #21

Made and filled by M. Nelson, 7-32nds.—7-32nds.—3 x 350 cable, 4 x 18 inch lead sleeve, 350 sq. end connectors.

mill conductor insulation sq. ended. Gap between mill insulation and end of connector 1/8 inch. Gaps filled with rope which had been soaked for ten minutes in stanolene at 270 F. Conductors insulated with six (6) mill paper, to the height of 350 gauge, each layer being treated with stanolene (=1 thinner). Jacket six (6) mill paper applied to the height of 350 gauge, each layer being treated with stanolene (=1 thinner). This splice was filled with insulene to which had been previously added, at the factory, 10% stanolene at 27 inch vacuum. Filler prepared by being dehydrated at 270 F. for twenty (20) minutes, and then reduced by radiation to 230 F. and poured at that temperature.

Splice =22

Made and filled by M. Nelson 7-32nds.—7-32nds.—3 x 350 [fol. 553] cable. 4 x 18 inch lead sleeve, 350 sq. end connectors, mill conductor insulation sq. ended. Gap between mill insulation and end of connector 1/8 inch. Gaps filled with rope which had been soaked for ten minutes in stanolene at 270 F. Conductors insulated with six (6) mill paper, to the height of 350 gauge, each layer being treated with stanolene (=1 thin-er). Jacket six (6) mill paper applied to the height of 350 gauge, each layer being treated with stanolene (=1 thinner). This splice was filled with insulene at 27 inch vacuum. Filler prepared by being dehydrated at 270 F. for twenty (20) minutes, and then reduced by radiation to 230 F. and poured at that temperature.

Respectfully, —— ——.

HH JQ.

Plaintiff's Exhibit No. 44

Feb. 19, 1915.

Mr. A. Rabe, General Foreman.

Dear Sir: The following splices have been made for test at Vam Dam St.;

Splice =23

Made and filled by M. Nelson. 8 1/2 32nds.—4 32nds. 3 x 350 cable, opening lead to 17", length of conductors from

end of lead 8½", special lead sleeve lower portion, half [fol. 554] round 2½" radius, upper portion rectagular 2½" high and 5" wide

350 connectors tapered ½" on each end. Mill conductor insulation tapered 1". Gap between end of connector and end of mill insulation ⅛". Space between highest point of taper of mill insulation and highest point of taper of connector was filled with insulene in plastic state about 100 F., then rope filler, which had been soaked in Stanolene, at 250 F. for ten minutes, was tightly wrapped in this space so as to force the Insulene up between the separate turns of rope filler, until space was completely filled; conductors were then insulated with six (6) mill paper to the height of 11 32nds. inches over the mill insulation at highest point of mill insulation tapering; each layer of paper being treated with Stanolene (=1 thinner). Jute which had been previously soaked for ten minutes in Stanolene (=1 thinner) at 250 F. was then placed between conductors so as to fill space completely, and act as a wick to hold the filling compound in suspension. 1¼" of mill insulation of belt was left on cable, ¾" of which was tapered, six (6) mill paper was then applied to the height of 5 32nds. inches over the conductor insulation, each layer being treated with Stanolene. Around the hand applied belt, there was applied copper ribbon ¾" wide and one (1) mill thick, this ribbon was placed under lead armor, which had been previously "Belled out" for that purpose at both ends of the splice, and soldered to it, each turn overlapping the previous turn by ¼". The special sleeve was placed over splice, off center, so that the bottom of splice touched the inside [fol. 555] of lead sleeve leaving about ½" space above the insulation; this space to be completely filled with compound.

Vacuum pump was connected to splice, but when ten (10) inches of vacuum was reached the lead sleeve gave indication of collapse, and pumping was discontinued and splice was filled with Stanolene (=1 thinner) at atmospheric pressure.

Splice =24

Made and filled by M. Nelson. 8½ 32nds.—4 32nds. 3 x 350 cable, opening lead to lead 17" length of conductors from end of lead 8½" 6" x 24" x 3 16" round lead sleeve. 350 connectors tapered ½" on each end. Mill conductor

insulation tapered 1". Gap between end of connector and mill insulation 1/8". Space between highest point of paper of mill insulation and highest point of taper of connector was filled with Insulene in plastic state about 100° F., then rope filler, which had been soaked in Stanolene at 250° F., for ten minutes, was tightly wrapped in this space so as to force the Insulene up between the separate turns of rope filler, until space was completely filled; conductors were then insulated with six (6) mill paper to the height of 11 32nds. inches over the mill insulation at highest point of mill insulation tapering, each layer of paper being treated with Stanolene (=1 thinner). Jute which had been previously soaked for ten minutes in Stanolene (=1 thinner) at 250° F., was then placed between conductors so as to fill space completely, and act as a wick to hold the filling com-
[Fol. 556] pound in suspension. 1 1/4" of mill insulation of belt was left on cable, 3/8" of which was tapered, six (6) mill paper was then applied to the height of 5 32nds. inches over the conductor insulation, each layer being treated with Stanolene. Around the hand applied belt there was applied a sheet of 100 mesh copper gauze, this gauze was placed under the lead armor, which had been previously "Belled out" for that purpose, at both ends of the splice, and soldered to it. Gauze was folded at different places to take care of its slack due to the difference in the perimeter of different parts of the splice, and bound around with twine to make the gauze bear on the entire structure of the splice. The lead sleeve was placed over splice, off center, so that bottom of splice touched the inside of lead sleeve, leaving 1 1/2" space above the insulation; this space to be completely filled with compound. This splice was filled with Stanolene (=1 thinner) at 28" vacuum.

Splice =25

Made by J. Brennan and filled by M. Nelson. 8 1/2 32nds. —4 32nds. 3 x 350 cable, opening lead to lead 17", length of conductors from end of lead 8 1/2". 6" x 24" x 3 16" round lead sleeve. 350 connectors tapered 1/2" on each end. Mill conductor insulation tapered 1". Gap between end of mill insulation and end of connector 1/8". Space between highest point of taper of mill insulation and highest point of taper of connector was filled with Insulene in plastic state

about 100° F., then rope filler, which had been soaked in Stanolene, at 250° F. for ten minutes, was tightly wrapped [fol. 557] in this space so as to force the Insulene up between the separate turns of rope filler, until space was completely filled; conductors were then insulated with six (6) mill paper to the height of 11 32nds. inches over the mill insulation at the highest point of mill insulation tapering; each layer of paper being treated with Stanolene (#1 thinner). Jute which had been previously soaked for ten minutes in Stanolene (#1 thinner) at 250° F. was then placed between conductors so as to fill space completely, and act as a wick to hold the filling compound in suspension. $1\frac{1}{4}$" of mill insulation of belt was left on cable, $\frac{3}{8}$" of which was tapered, six (6) mill paper was then applied to the height of 5 32nds. inches over the conductor insulation, each layer being treated with Stanolene. The lead sleeve was placed over the splice, off center, so that bottom of splice touched the inside of lead sleeve leaving about $1\frac{1}{2}$" space above the insulation, this space to be completely filled with compound. This splice was filled with Stanolene at 28" vacuum. After being permitted to remain for one (1) hour, all Stanolene which would flow off readily was then drained from splice, and splice was then filled with Insulene at atmospheric pressure.

Splice #26

Made by H. Schnessler and filled by M. Nelson. $8\frac{1}{2}$ 32nds.—4 32nds. 3 x 350 cable, opening lead to lead 17", length of conductors from end of lead $8\frac{1}{2}$". 6" x 24" x 3 16" round lead sleeve. 350 connectors tapered $\frac{1}{2}$" on each end. Mill conductor insulation tapered 1". Gap between end of connector and end of mill insulation $\frac{1}{8}$". [fol. 558] Space between highest point of taper of mill insulation and highest point of taper of connector was filled with Insulene, in plastic state about 100° F., then rope filler, which had been soaked in Stanolene at 250° F. for ten minutes, was tightly wrapped in this space so as to force the Insulene up between the separate turns of rope filler, until space was completely filled; conductors were then insul. with six (6) mill paper to the height of 11 32nds. inches over the mill insulation at the highest point of mill insulation tapering; each layer of paper being treated with Stan-

olene (=1 thinner). Jute which had been previously soaked for ten minutes in Stanolene (=1 thinner) at 250° F., was then placed between conductors so as to fill space completely, and act as a wick to hold the filling compound in suspension. $1\frac{1}{4}$" of mill insulation of belt was left on cable, $\frac{3}{8}$" of which was tapered, six (6) mill paper was then applied to the height of 5 32nds. inches over conductor insulation, each layer being treated with Stanolene. The lead sleeve was placed over splice, off center, so that bottom of splice toughed the inside of lead sleeve leaving about $1\frac{1}{2}$" space above the insulation, this space to be filled with compound. This splice was filled with lump rosin, about the size of white beans which had been previously dehydrated at the factory, and filling was completed with Stanolene at 28" vacuum.

Splice =27

Made and filled by M. Nelson. $8\frac{1}{2}$ 32nds. 4 32nds. 3 $\frac{3}{4}$" 350 cable, opening lead to lead 17", length of conductor from end of lead $8\frac{1}{2}$". 6" x 24" x 3 16" round lead sleeve. [fol. 559] 350 connectors tapered $1\frac{1}{2}$" on each end. Mill conductor insulation tapered 1". Gap between end of connector and end of mill insulation $\frac{1}{8}$". Space between highest point of taper of mill insulation and highest point of taper of connector was filled with Insulene in plastic state about 100° F., then rope filler, which had been soaked in Stanolene, at 250° F. for ten minutes, was tightly wrapped in this space so as to force the Insulene up between the separate turns of rope filler, until space was completely filled; conductors were then insulated with six (6) mill paper to the height of 11 32nds. inches over the mill insulation at highest point of mill insulation tapering; each layer of paper being treated with Stanolene (=1 thinner). Jute which had been previously soaked in Stanolene (=1 thinner) at 250° F., was then placed between conductors so as to fill space completely, to act as a wick to hold the filling compound in suspension. $1\frac{1}{4}$" of mill insulation of belt was left on cable, $\frac{3}{8}$" of which was tapered, six (6) mill paper was then applied to the height of 5 32nds. inches over the conductor insulation, each layer being treated with Stanolene. Around the hand applied belt, there was applied a sheet of 100 mesh copper gauze, this gauze was placed under the lead

armor, which had been previously "Belled out" for that purpose at both ends of splice and connected to it by soldering. Gauze was folded at different places to take care of its slack due to the difference in perimeter of different parts of splice, and bound around with twine to make the gauze bear on the entire structure of splice. Over the gauze was [fol. 560] applied white cotton wick 1½" wide, 3 32nds inches thick, one layer with edge butting adjacent edge, over the large section of splice and at smaller section of splice, toward the ends, layer over layer was applied so as to have a height which was a straight line over the entire length of splice. The lead sleeve was placed over the splice, off center, so that the bottom of splice touched the inside of lead sleeve leaving about 1½" space above the insulation, this space to be filled with compound. This splice was filled with Stanolene at 28" vacuum.

Splice #28

The construction of this splice is the same as splice #27, except that instead of using a 6" x ¾" x 316" round lead sleeve, placed off center, with 1½" space between top of conductor and top of inside of sleeve, a 7" x 30" x ⅛" round lead sleeve was used and was placed concentric with about ⅛" space between top of conductor and top of inside of lead sleeve.

General

Compound for filling splices except lump rosin used in splice #26 was prepared for use by being dehydrated for twenty (20) minutes at 250° F. and reduced to 230° F. by radiation and poured at that temperature.

Respectfully, H. Haggerty.

HH/JQ.

PLAINTIFF'S EXHIBIT No. 45

TEST 01775
BY Vandam
DATE 2/2/15

THE NEW YORK EDISON COMPANY
TEST DEPARTMENT
TESTERS

DATA SHEET

Splices received 2/2/15 AM.

Edison Splices

#19 4 x 18" Sleeve Number stenciled on wipe
Lead to lead 17½"
Waste ends filled w. tk. jute saturated with stano line
Paper applied 350 quake fill 2 end of mill insulation
Paper saturated with stanoline
Joint filled with Stanoline

#20 Made same way
Filled with stanolite

#21 Made same way
Filled with insulene 10% stanolene

#22 Made same way
Filled with insulene as from still

Standard Splice ... Has been subjected to heavy current

#23

Cross section of Sleeve

17" from lead to lead

(T-23) Connectors 2 tapered ¼ to gage 32" thick

Cable 3 x 4/32 Conductor Mill Insulation tapered fin. Insulene applied to gap Gap filled with rope previously treated with Stanolene Conductors wrapped with 6 M.I. paper stanolene between layers. ½ 2" outside diameter, at edges of Mill Insulation Total 12/32" thick over connectors. Jacket, similarity to 5/32" thick Over jacket from lead to lead, ¾" x .001 Copper ribbon, soldered to sheath at each end, lapped ¼ of its width

Rope filler, lengthwise, between conductors, treated with Stanolene

562

PLAINTIFF'S EXHIBIT No. 46

TEST 9117
AT Vanaam
DATE 2/11/5

THE NEW YORK EDISON COMPANY
TEST DEPARTMENT
TESTERS

DATA SHEET

Edison Splices

#23 Continued)

Splice subjected to 10 vacuum dry). Then [illegible] filled with Stanolene.

Mill outer belt extends within splice 1½", tapered for ⅜".

#24

6" Sleeve

Outer jacket wrapped in sheet of copper gauze [illegible] soldered to sheath.

Filled under 28" vacuum with Stanolene

Conductors at bottom of bell [illegible] same.

Other specifications, same as for #23.

#25 8½ × 4/32 Gable -

Gaps ¼" Insulene tape - filled with rosin soaked insulene [illegible] 10 min. - Head wrapping 1½ [illegible] Mill Cord. Insulene tape [illegible] 1½ × Mill Jacket

Mill jacket 1¼", ⅜ tapered.

6" Lead Sleeve - Filled with stanolene; after the excess drawn off splice filled with insulene at atmosphere

#26 Same except filled with dehydrated rosin in lumps the size of peas, and Stanolene at 28" Vac.

563

PLAINTIFF'S EXHIBIT No. 47

TEST 01775 — THE NEW-YORK EDISON COMPANY — TESTERS JRP 6/9 12
AT Vandam — TEST DEPARTMENT — MAP (12 8)
DATE 2/2/15 — DATA SHEET — HP Log

AV

50
OP (8-4)

2/2/15				
AM			74	
9 35	Off to rearrange conductors & oil		47	05
9 40	On again		12	
2/3/15				
2:40	Off to fill ends with oil			
2:45	On at 50,000 volts			05
7:18	Blasted #19 out, moisture in primary end			
7:25	On at 50,000 volts	5m	21	07
9:20	U #19 taken out			
9 25	Edison #19 (oil splice) put in - length put on			05
11 47	Shut down to oil			
PM 1 53	On at 50,000 V			06
1.17 PM	OH to fix leads			
1.20	On at 50,000 V			07
7:42	Off for oil			
7:48	On - 50 KV.			06
2/4/15	Safety out, test down primary end across delta	6 hrs 4 min		
2:29	#19	60 " 9 "		
2:30	On at 50,000			112
8 52	Arc over H off. U + 20 went	61 hrs 54 m ✓		
10 02	Ed #20 (oil feeble) put in - at 50 KV			1 12
	Ed " 21 "			
1 05 PM	Off to use transformer for other test.			
5:15 PM	On - 50 KV.		410	
7 02	Off to check U #20			09
7 11	On 50 KV.			
2/5/15	Off to refill with oil			
3.45	on at 56,000			05
11 01 AM	Off to fix leads			
11 05 A	on 50,000 volts			02
2:27	off to fix leads			
2 30	on at 50,000 volts			03
6:15	Off for oil.			
6:25	On 50 KV.			10
12:00	Off over Sundays			

Time to 2/6/15 12 00 PM	Oil Splices	Ed #19	Ed # 20	Ed # 21
		80 hr 15 m	57 hr 12 m	57 hr 12 m

1747-167
563

564

PLAINTIFF'S EXHIBIT No. 48

TEST 01775 — THE N.Y. CITY EDISON COMPANY — (8 M)
BY Vanclum — TEST DEPARTMENT — TESTERS JRG 4-12 / JJ20 (12M)
DATE 2/8/15 — DATA SHEET

A3 High Pot. Log. Time up to This Sheet: Ed #19 - 80 h 15 m; 21 57 12

8:00 AM Layer of oil in each splice compartment, All OK.
8:20 Ed #20 (oil in box #1, Ex #21 oil in box #2 Ed #19 in box #3) on at 50 kV
8:42 Off arc over
8:51 On at 50 kV :09
9:00 Off to cut gas heater gen set
9:03 On at 50 kV :03
10:13 Off to increase kvx
10:18 On at 50 kV :05
3:23 Off arced over
3:26 On at 50 K.V. :03
8:10 Off for oil.
8:15 On 50 K.V. .05

2/9/15
PM
12:43 Off to put new kvx in
2:32 On 50 K.V. Same + Edison #22 New ← 1:49

2/10/15
12 Noon 2/9/15 -- Ed #19 - 129 h 41 min; #20-2 - 106 h 30 min. - #22 - 21 h 49 min
1:18 Off arcing
1:33 On 50 KV
7:55 Off for Oil
8:00 On - 50 K.V. .05

2/11/15
11:25 Off to remove leakage oil
11:50 On .25
11:53 Off arcing at low
12:00 On Ed #19 152 h 58 min #20-21 130 h 25 min #22 - 45 h 5 min .08
1:15 Off to fix oil
1:25 On at 50 K.V. .10
4:39 Off to refill tanks
4:45 On 50 K.V. .06
6:50 Off for oil
7:06 On - 50 K.V. .08

2/12/15
1:25 AM Off Ed # 22 breakdown Total Time Ed #22 - 58 h 16 m
1:30 On .05

PLAINTIFF'S EXHIBIT No. 49

DATA SHEET

High Pot Lab

6:30 AM Off to and fr
6:39 A.M. On
10:50 Off to remove Ed # 22 and install Ed # 24 .04
11:30 On Ed 19-20, 21-23 at 50 KV .40
11:50 Off arcing
11:51 On .01
12:55 Ed # 20 out failed performance test Total time to 12:55 o'clock 11:15
1:05 PM Ed # 19-21-23 on at 50 KV Ed 19-175 hrs 44 mm .10
Ed 20-154 hrs 11 mm
Ed 21-154 hrs 11 mm
Ed 23-1 hrs 42 mm

8:17 Off to install Ed # 24 - total 11 units
8:36 On 50 KV " 19 " 23 New 24 ← .19
12:19/14 Off for oil
12:03 ↓ On at 50 KV
9:55 → 9:55 a.m. Ed 19 196 hrs 23 mm
Ed 21 174 hrs 50 mm
Ed 23 22 hrs 04 mm
Ed 1 13 hrs 19 mm

PM
7:30 Off for Oil
7:35 On - 50 KV .53
10:05 Off for oil
10:10 On - 50 KV .05

2/19/15
AM

PM
5:00 Chart leads high
6:52 Off for oil
6:58 On 50 KV
11:05 Off for MB Set .06
11:33 On 50 KV .28
2-15-15
6:57 Off to chg m.g. Set
7:06 On at 50 KV .09

451
566

PLAINTIFF'S EXHIBIT No. 50

TEST Q1775
AT Windsor
DATE 2/26/1

TEST DEPARTMENT
DATA SHEET

TESTERS V. A. P. C.

Edison Splices

#27 - Similar to preceeding - Gauze-wrapped, gauze covered with lamp wick - filled with stanolene

28 Same as #27 but with 3" above one centre phase [illegible]

PLAINTIFF'S EXHIBIT No. 51

567

N. Y. EDISON CO. TEST DEPARTMENT

TEST RECORD

NO. [redacted] TEST H.P.F. [redacted] Compound Filled [redacted] ISSUED [redacted]

REQUESTED BY F.T. SEE Memo DUE [redacted]

REPORTED [redacted]

REMARKS: For conformity to [redacted] arrange [redacted] advise

[redacted] dan.

Closed Out F= 6-13-17

Jobs

MATERIAL	RECEIVED FROM	DATE	RETURNED TO	DATE	REMARKS

TESTED BY

CALCULATED BY

CHECKED BY

568

PLAINTIFF'S EXHIBIT No. 52

TEST 01735

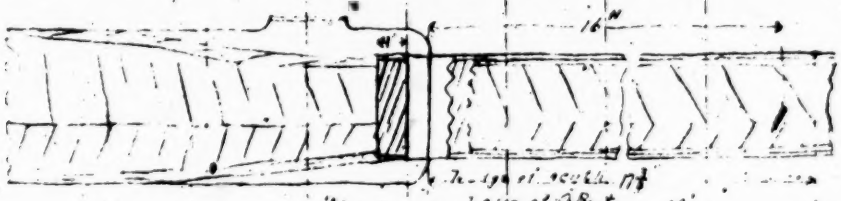
AT Vicksburg

DATE 7/13/15

DATA SHEET

Edison -20

4"x18" Sleeve-17" from lead to lead. Sq. end gaps filled with jute saturated with Stanolene - Paper applied to 3 conductor at end of mill insulation - Paper saturated with Stanolene - Joint filled with Stanolyte.



17" From opposite wipe to edge at sheath (not shown)

Paper in cable is well saturated. - Cable shows evidence of creeping of filling compound through pipe filler.

Total Time 1 54 hr 11 min.

3 coils 3/c.

PLAINTIFF'S EXHIBIT No. 53

TEST 01713
AT Vandalia
DATE 2/2/15

TEST DEPARTMENT
DATA SHEET

T.R.P. Co.
Nav.

Edison #23.

mm Path of Rupture
5# from Mill Belt

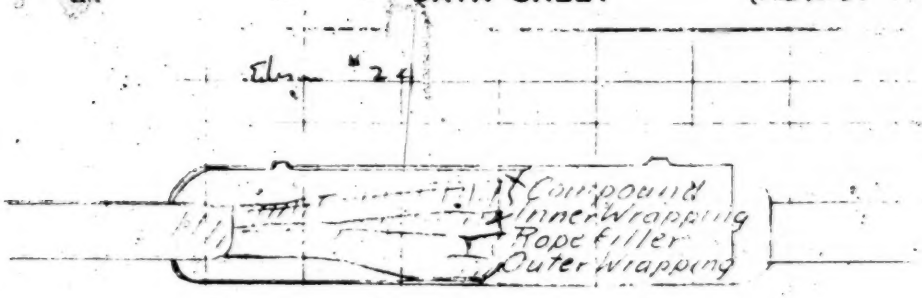
Splice was impregnated. Copper, ribbon & lt. lighter than gauze.
Broke [illegible] between edges of connectors.
Semi Pulled 74 hrs 12 min Drawn 16 hrs 33 min Refilled 13 hrs 00 min
Steady 5 hrs 18 min Total 107 hrs 59 min.

455
570

PLAINTIFF'S EXHIBIT No. 54

TEST DEPARTMENT

DATA SHEET



Chain from all seem to have penetrated ends & splices
No lamp wick
Wipers not used Light smoke on both. wiped copper
Splices well impregnated
Breakdown in center of splice - between end & connectors
Total time 2 hr 19 min 37 min

82 350 000 CM 8 4/32 Page 9.

6" sphere. Gauge, no lamp wick. Chamber filled.
see Room memo of Feb 19.

PLAINTIFF'S EXHIBIT No. 55

58

TEST

AT Vaudreuil

DATE 2/2/15

DATA SHEET

Edison #25 · Involute filled

Conductors connected in series - Current 350 amps

Start 4:00 PM Temp 21°C at Sheath

5:35 Ambient 21°C

Thin thin epoxy at ends of splice Strain too high

Gauges 400 - 800 - 3200 Emics

to be transferred Oil

6:00	Temp. of Sheath 22°C		
	Conductor at end of sheath		32
8:00	Sheath	24°C	
	Conductor		36
10:00	Sheath	24°	
	Conductor		37°
3:00	Sheath	25°	
	Conductor		37
6:00	Sheath	26	
	Conductor		38°
8:00	Sheath	27°	
	Conductor		37°
10:00	Sheath	27°	
	Conductor		38.5
12:00	Strain 400 1125 4200 Gauges		
	Sheath	28.5°	
	Conductor		48.0°C
2:00	Strain	33°C	
	Conductor		53°C
4:00	Sheath	33°C	
	Conductor		53°C
6:00	Sheath	32.5°C	
	conductor		51°C
8:00	Sheath	31°C	
	Conductor		50°C
10:00	Sheath	31.0°C	
	Conductor		51°
12:00	Sheath	31.0°C	
2-4-15	Conductor		51°C
2:00	Sheath	26	
	Conductor		37

457
572 PLAINTIFF'S EXHIBIT No. 58

TEST
AT Vandam
DATE 2 4 15

TEST DEPARTMENT
DATA SHEET

51

H.P.

Edison 1:25 Phenolem filled
Conductors in series 450 amps

4:00	Sheath	28	
	Conductor		54
6:00	Sheath	30	
	Conductor		54
8:00	Sheath	28	
	Conductor		54
10:00	Sheath	30.0	
	Conductor		53
12:00	Sheath	31.5	
	Conductor		50
1:00	Sheath	0	
	Conductor		50°C

taken off
This test was made to see how Compound would run off under temperature
Only a very small amount ran off — about 1/2

458
573

PLAINTIFF'S EXHIBIT No. 57

TEST 2

AT Vo

DATE 2-6-15

TEST DEPARTMENT

DATA SHEET

T.P.G.

Edison #27

Lamp Wicking well saturated after draining for examination) Gorge strapped with string - not tightly enough. Space within outer jacket well saturated Broken down under edge of sheath in splice.
Inner - filled 2 hrs 37 mins Drained 136 hrs 33 mins Refilled 12 hrs 0 mins
Heated 7 hrs 11 mins Total 181 hrs 16 mins

459
574

PLAINTIFF'S EXHIBIT No. 58

TEST 217
AT Vaud
DATE 2/5/15

TEST DEPARTMENT
DATA SHEET.

TESTERS J.R.L. Vail

Design 29

strip
N.I.
54 2 4
No. 58
2/7.

Glaze not tight enough. Pape filler wall separated
Broken down between centers of connectors
Cu. fuses 0" Dia 0.9 mm Nickel Clad 35 mm at 110 Ma 4 mm

PLAINTIFF'S EXHIBIT No. 59

LB-32 50M—7-34

TEST [illegible]

AT Van Nuys

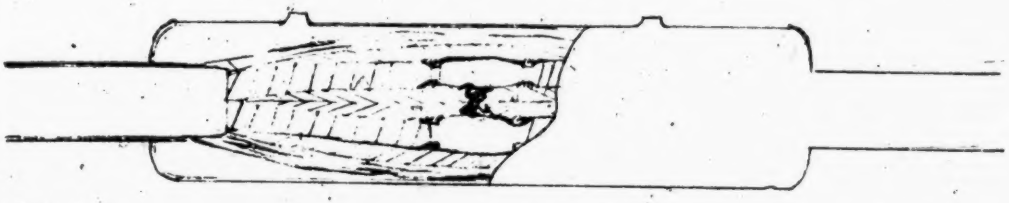
DATE 2-21-35

ITEM DEPARTMENT

DATA SHEET

TESTERS [illegible]

Edison #30



Splice broken down between connectors

Temp { with 0 hrs 26 mm
70°C - 8 hrs 42

Total hrs 9 hrs 68 mm

[fols. 576 & 577] PLAINTIFF'S EXHIBIT No. 60

In re 22,000 Volt Cable Joints

November 11, 1914.

Messrs. J. W. Lieb, Frank W. Smith, A. Maxwell, W. E. McCoy, J. B. Noe, A. Rabe:

Referring to last week's and this week's splice burnouts on feeders 201 and 202, these burnouts were all on remade joints. From the investigation made there seems to be no doubt that the cause of the burnouts is due to the fact that the manufacturer's insulation on the individual conductors of the sector cable has wrinkles which extend from the metal union outward and cause air interstices to exist between the mill insulation and the hand wrapping. These interstices are not filled by the filling compound, which fails to penetrate into the inner layers.

The fact also that the insulation is cut sharp at right angles to the copper conductors without tapering off has made this weakness more pronounced than it would have been if the proper tapering of the insulation had been applied. This matter will be the subject of another memorandum.

The characteristics of the burnouts give sufficient evidence to confirm the above explanation of the causes of the burnouts.

The remedy will consist either (1st) in tapering the manu- [fol. 578] facturer's insulation and applying the hand wrapping with a liquid binder around the conductors and between layers, so that the joint will be uniformly saturated before the paraffine filler is poured in, or (2nd) by using mica tubes around each single conductor and a mica tube over all three conductors, then filling the joint by the use of the vacuum machine.

This method will especially be used on the 22,000 volt cables for the New Haven service. For that service, tubes will be 7" long. The manufacturer's insulation around each conductor will be slightly tapered to allow an easy flow of the filling compound into the space around the conductor. The joint will be filled by the use of the vacuum machine

with a rosin and asphalt compound having a melting point of about 200° F. and to be poured at 300° F.

One of these joints so made by Mr. Rabe, except that the tubes are 5" long instead of 7", has been sent today to Mr. Maxwell prepared for a sustained high voltage test, the intention being that about 50,000 volts be applied and kept on the joint indefinitely, unless breakdown occurs. Mr. Maxwell will please notify me of the time when the test is started and at short intervals as to results. If the joint will stand for a long period, the voltage will be raised to 70,000 or 75,000 volts until breakdown occurs when the joint will be cut apart for a physical inspection of the filling.

All of this work is of pressing importance and the parties interested should give it their prompt attention.

Philip Torchio, Chief Electrical Engineer.

PT/D.

[fol. 579] PLAINTIFF'S EXHIBIT No. 61

January 30, 1915.

Standard Chemical Company,
Attention Dr. M. Zamatolski, Treasurer,
5th Street and Avenue A,
Bayonne, N. J.

GENTLEMEN: Confirming telephone conversation of this morning, will you kindly enter our confirming order for 100 pounds of stanoline. It is undersotod that you are to ship at once, 32 pounds in quart cans to our Mr. Krass, 15th. Street and Irving Place, and the balance is to be shipped, by express, in gallon tins to 715 First Avenue, The New York Edison Company, New York City, attention of Mr. Rabe.

Te total price of the above material is to be $6.00 not, f. o. b. New York and delivery is to be made at once.

Yours very truly, —— ——.

RWK/RL.

[fol. 580] PLAINTIFF'S EXHIBIT No. 62

(Letterhead of Standard Chemical Company)

Jan. 30, 1915.

Mr. Ralph W. Krass, New York.

DEAR SIR: We send you herewith 16 one quart cans of Stanoline as requested over telephone this morning.

Yours very truly, Standard Chemical Company,
R. F. Smith.

MS/RF.

PLAINTIFF'S EXHIBIT No. 63

(Letterhead of New York Edison Company)

February 8, 1915.

Mr. Philip Torchio, Chief Electrical Engineer:

I herewith submit description of the various rosin oil compounds which are being tried out on joints under test recently made by Mr. Rabe:

1st Stanoline

This is the pure distilled rosin oil obtained from rosin during process of distillation and is the by-product which is subsequently mixed with the treated rosin (Insoline) in the proper proportions so as to give a saturating oil (Stanolite) of the desired viscosity. This oil will flow freely between the temperatures of 220° F. and 10° below zero.

[fol. 581] 2nd Stanolite

This is a cable oil and is obtained by simply mixing in the proper proportion the Stanoline and Insoline so as to obtain the desired viscosity. The viscosity of this oil with about 40% of Insoline, is 190 at 97° C. This compound will flow freely at about 235° F. and will not flow at about 5° below zero. Becomes viscous at 90° to 100° F.

3rd Insoline

This is the treated rosin and is the by-product that is obtained after distilling off all the impurities from the raw rosin. Becomes viscous at about 130°—140° F.

4th Insoline plus 10% of Stanoline

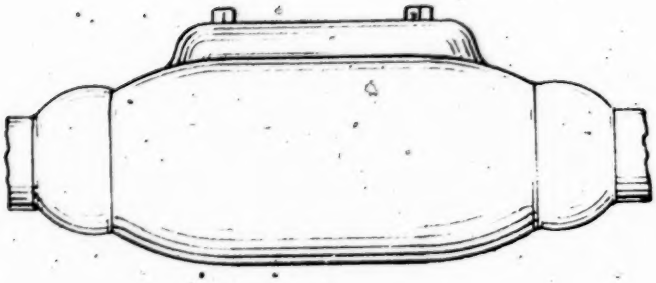
This is perhaps better suited as a joint filling compound than Insoline, as the addition of 10% of Stanoline would prevent the compound from ever becoming solid or changing from an amorphous to chrystalline structure. It would also have the added advantage of flowing a little more freely at the temperature of about 230° F. than Insoline. Becomes viscous at about 120° F.

All of the above compounds, when used during process of filling a joint, should be heated at about 250° F. and allowed to cool down to about 220° F., at which temperature the compound should be poured into the joint to give the best results:

R. W. Krass.

RWK/RL.

PLAINTIFF'S EXHIBIT No. 64



...ICE UNITS. 26,400 VOLT. DOME TYPE. PART No. MS-55-D JOB No. 3794 SHEET 1 OF 2

8 12 CAT. No. DATE 8-24-26

ASSEMBLE 330 CABLE SPLICE UNITS. PT. #MS-55-D W.S.P.

COMPLETED

324 PUBLIC SERVICE PROD CO. P-29614 DATE 8-2-26

6 PUBLIC SERVICE ELEC & GAS CO. ORDER 101914 DATE 8-6-26 BALANCE

LINE	UNIT	DESCRIPTION	PART No.	QUANTITY	STOCK	VENDOR	ORDER	JOB	WEIGHT	UNIT PRICE	TOTAL
1	1	LEAD SLEEVE 6-1/2" I.D. X 5/32" WALL									
2		X 30" LONG.		330	50	NAT LEAD	22350				
3	1	CANS WRAPPING MATERIAL.	3614	330	324	SAFETY	22355				
4	3	CONNECTORS (SPECIAL)	5512-6	990	OUT	NAT TELE	22124				
5	2	BUSHINGS	3569	660	OUT			3794-5			
6	2	PLUGS (DEPRESSED SQ.)	3601	660	out	Kilmer	27137				
7	1	STOCKING 27-1/2" LONG OVERALL									
8		#30 MESH #31 WIRE X 36" WIDE COP.GZE.		330 FT	X						
9	2	BRASS PIPE CAPS 1-1/4" STD		660							
10	1	BAR 40-60 PIG LEAD 7-1/2# EA.		330	out	Nat Lead	27629				
11	1-1/2 oz	STRIP SOLDER		31 #	X						
12		SOLDERING FLUID.									
13	6	WHITE PASTERS 2-1/2"X12" (GUM PAPER.		1980	X						
14	1	PCE THIN MUSLIN 6"X24"		330 PCS	X						
15	1	" EMERY CLOTH #0 3" X 11"		330 "	X						
16	2	LABELS FORM 80-B	3720	660	out						
17	1	" "	3747	330	out						
18	~~1~~	" " ~~80~~		~~330~~							
19	6oz	SELECT WHITE WASTE ENDS		124 #	OUT	Nat.	27631				
20	2 oz	STRIP SOLDER FOR STOCKING		42 #	X						

SUPERINTENDENT

466
583

PLAINTIFF'S EXHIBIT No. 65

MATERIAL FOR CABLE SPLICE UNITS. 26,400 VOLTS. DOME TYPE. PART No. MS-55-D
FACTORY INSTRUCTIONS—No. 12 CAT. No.

ASSEMBLE 330 CABLE SPLICE UNITS. PT. MS-55-D

JOB No. 3734 SHEET 2 OF 2
DATE 8-24-26
W.S.P.
COMPLETED

324
6 FOR PUBLIC SERVICE ELEC & GAS CO. ORDER 101914 DATE 8-6-26

FOR PUBLIC SERVICE PROD CO. ORDER P-29614 DATE 8-2-26

BALANCE

LINE	UNIT	DESCRIPTION	PART No.	QUANTITY	STOCK	VENDOR	ORDER	JOB	WEIGHT	UNIT PRICE	TOTAL
1	1.6 OZ	SOLDERING PASTE		33 #	X						
2	5 FT	BROWN SEALING TAPE 3"		1650 FT.	X						
3	1	CARTON FOR LEAD SLEEVE	3754	330	OUT						
4	1	" " WRAP & COMP.	3587	330	OUT						
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
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COMPLETED
OCT 28 1926

SUPERINTENDENT

PLAINTIFF'S EXHIBIT 65-A

MATERIAL FOR SPECIAL NOTICE. 26,400 VOLT. DOME-TYPE. PART No. MS-55-D

FACTORY INSTRUCTIONS—No. 12 CABLE SPLICE UNITS. CAT. No.

INCREASE THE ABOVE JOB (#3794) BY 240 CABLE SPLICE UNITS PT. #MS-55-D

JOB SHOULD NOW CALL FOR 570 UNITS PT. #MS-55-D

JOB No. 3794 SHEET OF

DATE 9-14-26

W.S.P.

COMPLETED

290 UNITS FOR PUBLIC SERVICE PROD CO. ORDER P-31043 DATE 8-30-26

10 " FOR PUBLIC SERVICE ELEC. & GAS CO. 107140 8-31-26

BALANCE

LINE	UNIT	DESCRIPTION	PART No.	QUANTITY	STOCK	VENDOR	ORDER	JOB	WEIGHT	UNIT PRICE	TOTAL
1		SOLDERING PASTE		5 #	X						
2		BROWN SEALING TAPE. 3"		1000 FT.	X						
3	1	CARTON FOR LEAD SLEEVE	3754	240	OUT	T & N	22634			District	
4	1	" " WRAP. MATERIAL.	3587	240	OUT	" " "	"			E.D N.Y.	
5										547	
6										65-B	
7	2	CANS COMPOUND		1140	OUT	Lafetra 2-1947				4pt 2v/3v	
8											
9		"NOTE" 660 CANS TO APPLY TO JOB #3794 ISSUED 8-24-26									
10		480 " " " " SPECIAL NOTICE. OF 9-14-26									
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COMPLETED

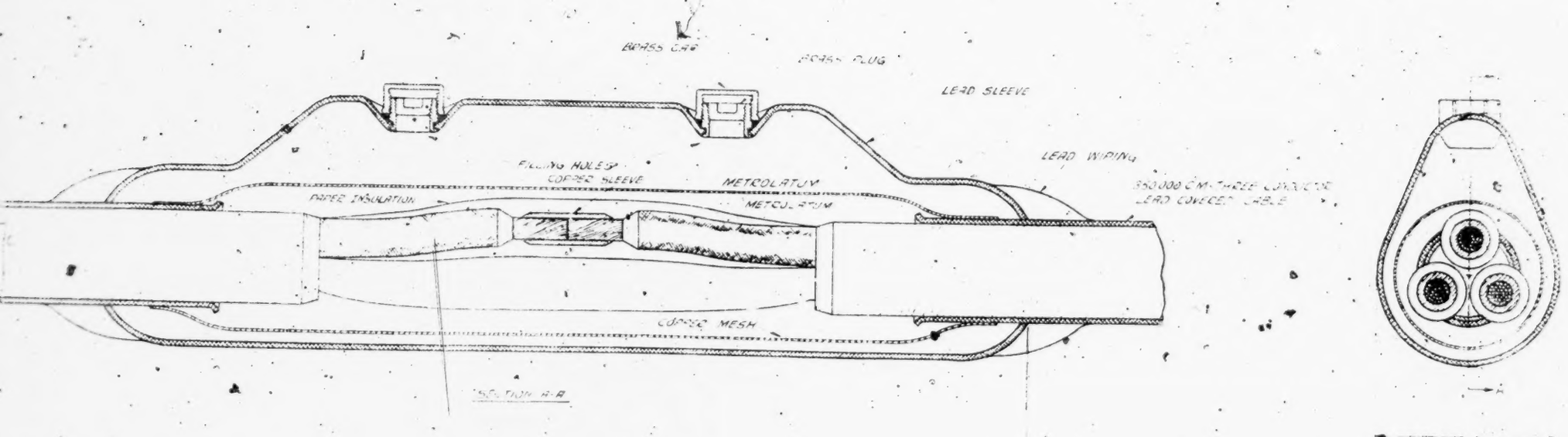
FEB 1 1927

SUPERINTENDENT

468
585

PLAINTIFF'S EXHIBIT 65-B

586
PLAINTIFF'S EXHIBIT No. 66



FIRST USE FOR PUBLIC SERVICE, NEWARK N.J.

MS-55D

ASSEMBLY OF 30" DOME TYPE CABLE JOINT
FOR 26,400 VOLT SERVICE

METROPOLITAN ELECTRIC CABLE CO.
1250 ATLANTIC AVE
BROOKLYN N.Y.

DRAWN BY G.C.STAUDEN
DATE 10-14-26
APPROVED BY

389?

[fol. 587] PLAINTIFF'S EXHIBIT No. 68

Patents and Designs Acts, 1907 to 1928

I, the undersigned, being an officer authorised by the Board of Trade under Section 62 (3) of the Patents and Designs Acts, 1907 to 1928, hereby certify that in pursuance of the applications of John Francis Watson and Callender's Cable & Construction Company, Limited, numbered 29,756 of 1913, 1,850 of 1914 and 8,828 of 1914 a single Patent was granted on the 24th April, 1915, and sealed as of the 24th December, 1913, under the provisions of Section 16 of the Patents and Designs Act, 1907.

This certificate is issued for use in the United States of America.

Witness my hand this 24th day of March, 1932.

M. F. Lindley. (Seal of the Patent Office.)

The Patent Office, 25 Southampton Buildings, London, W. C. 2, England.

GREAT BRITAIN AND IRELAND,
London, England,
Consulate-General of the United States of America, ss:

I, J. F. Claffey, Vice-Consul of the United States of America, at London, England, do hereby make known and [fol. 588] certify to all whom it may concern, that the signature "M. F. Lindley" subscribed to the annexed Certificate, is of the true and proper handwriting of M. F. Lindley, Assistant Comptroller of the Patent Office, London, England; that the seal affixed to the said Certificate is the seal of the Patent Office, London, England, and that to all acts signed as the annexed full faith and credit are and ought to be given in Judicature and thereout.

In testimony whereof I have hereunto set my hand and affixed the Seal of the Consulate-General of the United States of America, at London, England, aforesaid, this 29th day of March, 1932.

John F. Claffey, Vice-Consul of the United States of America, at London, England. (Seal.)

Service No. 2945.
Fee $2 = 11 s. 4 d.
(Fee Stamp—$2.00—American Foreign Service.)

23—611.

PLAINTIFF'S EXHIBIT No. 69

N° 15,413 A.D. 1909

Date of Application, 1st July, 1909—Accepted, 7th Oct., 1909

COMPLETE SPECIFICATION.

"Improvements in and relating to the Jointing of Electrical Conductors."

I, CHARLES VERNIER, Electrical Engineer, of 32, Bath Terrace, Gosforth, Newcastle-on-Tyne, in the County of Northumberland, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

The invention relates to the jointing of electrical conductors.

A common method of jointing cables at present employed is to insert the ends of the cable to be jointed into a sleeve, which is then soldered in place. Owing however to the irregular cross-section of the cable in many instances it is difficult on account of the substantial rigidity of the sleeve to secure good metallic contact.

The main object of the present invention is to overcome these difficulties.

To these ends the invention consists in a process of jointing electrical conductors according to which connections formed of a large number of fine wires are first disposed so as to bridge the joint and thereafter secured to the ends of the conductor by any suitable means with or without the use of soldering material.

The invention also consists in a joint for electrical conductors in which the connections bridging the joint are composed of a large number of wires preferably woven together so as on the one hand to render the bridging connections laterally flexible, and on the other hand to provide interspaces into which the soldering material can run.

The invention further consists in the specific processes and joints hereinafter described.

Referring to the accompanying drawings which illustrate my invention,

Figure 1 shews a side elevation and

Figure 2 an end view of one form of joint.

Figure 3 shews a sectional elevation of a telescopic joint formed according to my invention.

Figure 4 shews a plan of the outside layers of the cable illustrated in Figure 3.

Figure 5 shews a sectional elevation of a modified form of joint to that shewn in Figure 3.

Figures 6 and 7 shew sectional elevations of a half lap joint.

In carrying the invention into effect according to the form shewn by way of example in the drawings, three lengths of woven copper braid, *a*, are arranged to bridge the joint between the ends of the cables *b*, *c*, these lengths of braid preferably touching along their adjacent edges, and are then bound in place by the copper wire, *d*. Owing to the lateral flexibility of the braid, it readily adapts itself as seen in the end view, to irregularities in the cross section of the cables, and is likewise for the same reason forced to some extent between the strands themselves by the pressure of the binding thus forming a very effective joint. In some cases the joint may be finished in the ordinary way by pouring soldering material over the joint, the soldering material with the help of any suitable flux finding its way between the fine wires of the

[*Price 8d.*]

474
590

Improvements in and relating to the Jointing of Electrical Conductors.

braid, and in effect converting the lengths of braid into a solid sleeve in intimate contact with the cable over a considerable area.

In Figures 3 and 4 I have illustrated one method of constructing a telescopic form of joint according to my invention. In these figures the central cores, *e*, of the cable ends butt against one another as shewn while the layers concentric to the cores have alternate strands cut off at the points, *f*, and *g*. The remaining strands on both ends of the cable are then interleaved with one another as shewn in Figure 4 and on the outside copper braided tape, *a*, is disposed and secured in the manner hereinbefore described.

In Figure 5 I have illustrated a modification of the form of joint shewn in Figure 4. In this figure the ends of the cables to be jointed are cut back so as to form a series of stepped layers as shewn. The ends of the cores, *e*, are then caused to butt and the spaces between the stepped layers filled in with pieces, *h* and *i*, of copper braided tape. The joint is bridged on the outside by other pieces, *a*, of copper braided tape as before which are secured in place by wire, *d*, and soldered if desired.

In Figures 6 and 7 another form of joint is shewn in which the ends of the cable or conductor, *b*, *c*, are half checked and fitted to one another, copper braided tape, *a*, being disposed as before so as to bridge the joint.

Although I prefer in general to use woven braid as described, I may in some cases use a multiplicity of fine wires merely bunched or bundled together to bridge the joint, or in other cases I may use a woven tube of fine wires.

It will be seen that my invention is applicable not only to the joints illustrated by way of example, but also to other forms at present in common use.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. A process of jointing electrical conductors according to which connections formed of a large number of fine wires are first disposed so as to bridge the joint and thereafter secured to the ends of the conductor by any suitable means with or without the use of soldering material, substantially as described.

2. A joint for electrical conductors in which the connections bridging the joint are composed of a large number of wires preferably woven together so as on the one hand to render the bridging connections laterally flexible, and on the other hand to provide interspaces into which the soldering material can run, substantially as described.

3. Improved jointing processes and joints so produced substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 1st day of July, 1909.

MARKS & CLERK,
18, Southampton Buildings, London, W.C.,
13, Temple Street, Birmingham, and
30, Cross Street, Manchester.
Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1909

A.D. 1909. JULY 1. N° 15,413.
VERNIER'S COMPLETE SPECIFICATION.

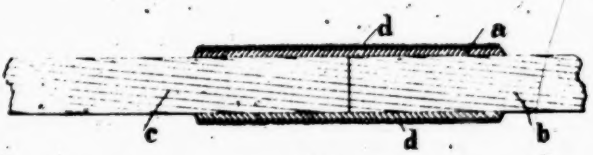


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

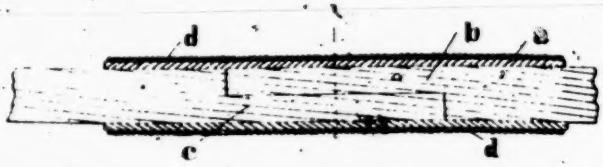


Fig. 6.

Fig. 7.

[This Drawing is a reproduction of the Original on a reduced scale.

Malby & Sons Photo Litho

476 PLAINTIFF'S EXHIBIT No. 70

J. SACHS.

ELECTRIC SWITCH.

APPLICATION FILED DEC. 19, 1918.

1,292,081. Patented Jan. 21, 1919.

2 SHEETS-SHEET 1.

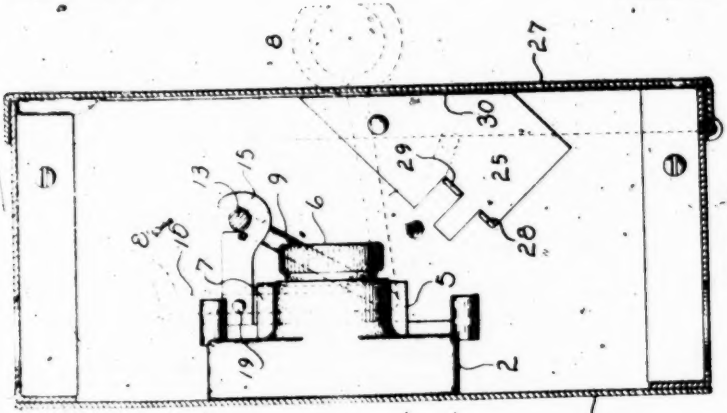


Fig. 2.

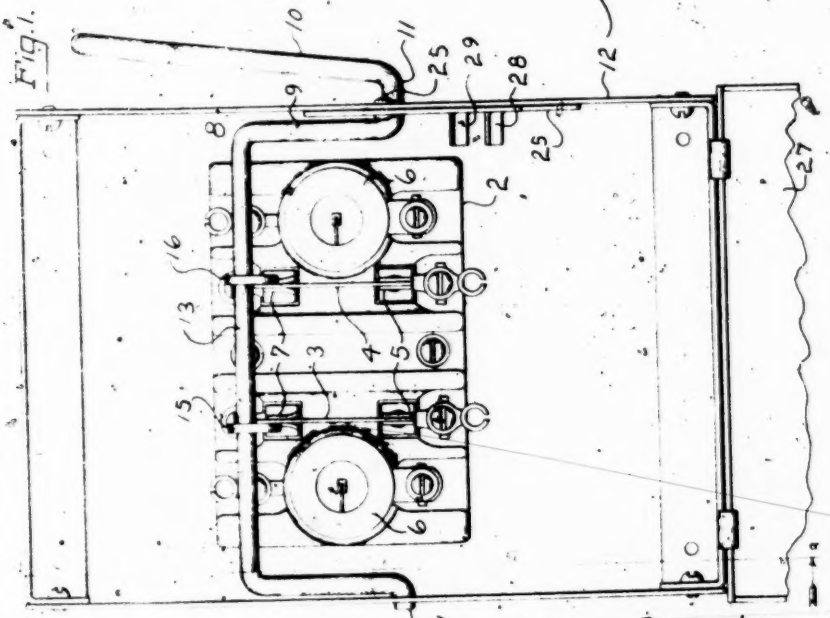


Fig. 1.

Inventor
Joseph Sachs
By Hutt & Lehmann
Attorney

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477

J. SACHS.

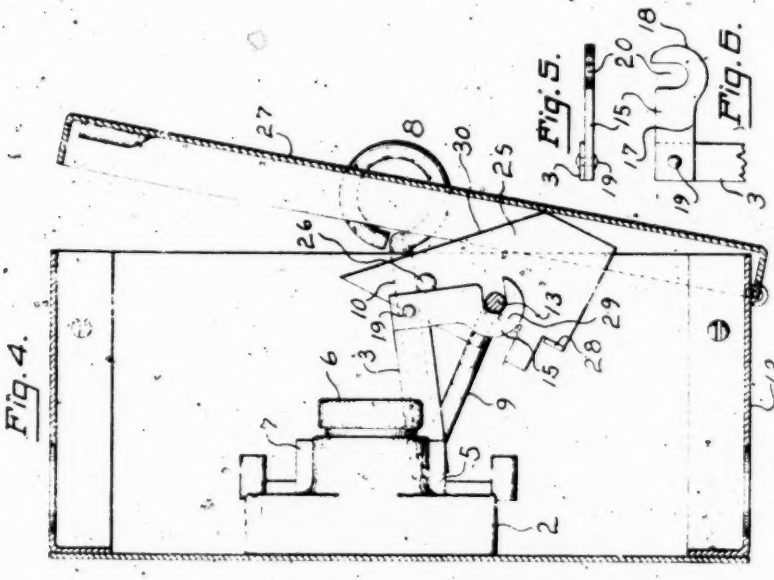
ELECTRIC SWITCH.

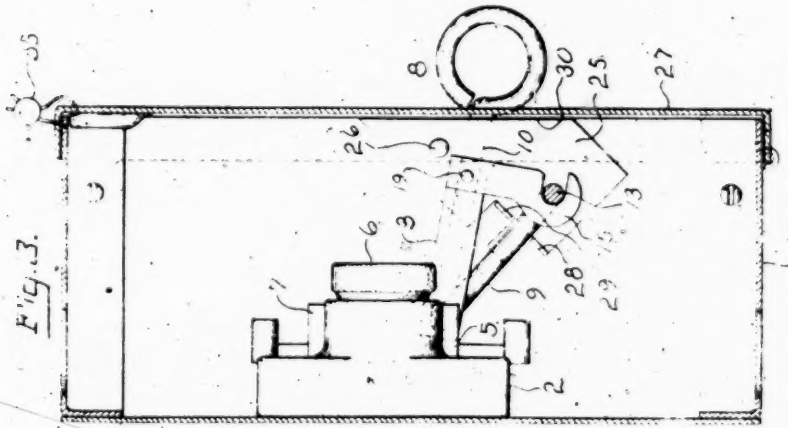
APPLICATION FILED DEC. 15, 1916.

1,292,081.

Patented Jan. 21, 1919.

2 SHEETS—SHEET 2.





Inventor
James Sachs.
By Hunt Lowell
Attorney

UNITED STATES PATENT OFFICE.

JOSEPH SACHS, OF HARTFORD, CONNECTICUT.

ELECTRIC SWITCH.

1,292,081. Specification of Letters Patent. Patented Jan. 21, 1919.

Application filed December 19, 1916. Serial No. 137,781.

To all whom it may concern:

Be it known that I, JOSEPH SACHS, a citizen of the United States, residing at Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Electric Switches, of which the following is a specification.

This invention relates to electric switches. While the improvements are susceptible to general application in this art, at least one of the features thereof is of particular utility when employed in connection with a sealable incased or boxed switch. As to this particular feature I provide means of an effective and inexpensive character for locking the switch in one of its positions which in the present case is the open position when the box is sealed.

In certain types of switches it is common to provide a plurality of connectors or switching members and an actuator therefor, the actuator being supported independently of the connectors or switching members. In these old forms the relation between the connectors or switching members is such that the switching members are not always brought into proper engagement with the coöperating contacts, by reason of which improper electrical connection follows when the switch is in the closed position. I provide a construction wherein this difficulty is eliminated.

In the drawings accompanying and forming part of the present specification I have shown in detail one of the many convenient forms of embodiment of the invention which I will set forth fully in the following description. I do not limit myself to this construction; I may depart therefrom in several respects within the scope of the invention defined by the claims following said description.

Referring to said drawings:

Figure 1 is a front elevation of an incased or boxed electrical switch involving the invention with the cover swung down to show the interior.

Figs. 2, 3 and 4 are longitudinal sections of the device shown in Fig. 1 on the line 2—3, looking in the direction of the arrow and showing the parts in different positions, the cover being closed in Figs. 2 and 3 and partly open in Fig. 4.

Figs. 5 and 6 are detail views in plan and side elevation of a coupling member for mechanically associating a switching member and an actuator.

Like characters refer to like parts throughout the several views.

While as I have already observed the invention is restricted in no sense as regards its use in any particular form of appliance, it is of peculiar importance when incorporated, certainly as to one of its features, in a sealable, incased or boxed switch. In the particular representation which I have selected for illustration, there is provided a suitable base as 2, generally of porcelain or some suitable insulating substance. This base or its equivalent is equipped with a plurality of connectors. I have only shown two denoted by 3 and 4 respectively. These connectors are of blade type. The number of connectors and their character does not concern the invention. The connectors or switching members as shown are pivotally supported by contacts as 5 of clip kind, these contacts pivotally receiving between their lips the connectors or switching members. The contacts 5 are provided with the necessary wire connecting means and are stationarily held to the base in some convenient manner as common in the art. The connectors or switching members may be either plain or fused, and when fused, the fuses may be of any desirable nature. I have shown them as plain or unfused but have illustrated the base 2 as equipped with fuses 6 of the well-known Edison plug type, and these are also provided with connecting means so as to be properly electrically connectible in circuit with the switching members or connectors 3 and 4. In addition to the contacts 5 there are complemental contacts as 7 which may be considered as rupturing contacts. These contacts 7 are also stationary upon the base 2 as familiar and each receives between its lips the rupturing portion of its coöperative connector or switching member as 3 and 4. The stationary contacts coöperative with each of the connectors are provided with suitable circuit wire connecting means.

In conjunction with connectors or switching members, of which those denoted by 3 and 4 are merely one of several different examples, I provide an actuator or switch operating member which is related with the connectors or switching members in a highly novel and advantageous way. It is old in the art to provide a plurality of connectors

and a crossbar or crosshead, to which these connectors are rigidly mechanically united. Where each of the connectors serves in a separate pole the crosshead or crossbar is usually made of insulating material, so that while mechanically united, the separate or individual connectors still remain electrically separate. It is usual to provide means such as a handle mechanically secured or attached to the crosshead or forming a part thereof whereby said switch may be manipulated, and where a separate actuator is employed, the crosshead and the actuator are usually connected mechanically by some means extending from the crosshead to the actuator. In the present construction I eliminate or dispense entirely with this crosshead or crossbar and its inherent defects and difficulties in bringing about proper alinement of the connectors mechanically secured to the crosshead and the stationary rupturing end contacts into which the rupturing portions of the connectors are received.

I provide a construction wherein although the connectors or switching members are coupled together for simultaneous closing and opening movement, yet there is provision for individual or independent movement; that is to say each connector or switching member is adapted to have a certain amount of free movement with respect to its operating element of whatever nature the same may be, the result being that the connectors when moved in either direction automatically aline themselves with their rupturing portion contact into and out of which they are moved, so that I remove the drawbacks to which I have alluded. This peculiar condition I secure in the organization shown, by proper couplings between the connectors or switching members and their actuator in such way as to interfere in no wise with the movement of the switching members or connectors with the actuator, yet still permitting individual automatic or self-alining action by providing for instance, between each of the connectors and the actuator, an individual coupling. It should be understood that as to this particular phase of the invention, the switch may be either boxed or unboxed.

I will describe an actuator and a coupling between each connector and actuator which has been found satisfactory, but as will be clear I am in no sense restricted thereto. Such an actuator is that denoted in a general way by 8. This actuator as shown comprises a bail-like part 9 and a handle as 10. The sides of the bail or yoke-like part are provided with outwardly extending pivots or gudgeons as 11 extending through perforations in the side walls of the box or casing 12 to the back or bottom of which the insulating base 2 already described, is suitably affixed. One of the pivots or gudgeons 11 connects the bail or yoke-like part 9 and handle 10. This handle serves as a convenient means exteriorly of the box for effecting the operation of the actuator 8 and therefore the connectors or switching members 5 and 6. The body portion 13 of the bail-like part 9 presents the operating portion of the actuator and is associated with the connectors through the medium of the individual coupling means whereby each connector is individually coupled with the operating portion of the actuator.

The coupling means between the actuator and the individual connectors or switching members may be of any desirable nature. I have shown for this purpose two couplers as 15 and 16 both alike, and each such as the coupler 15 being shown in detail in Figs. 5 and 6. It is understood that the connector or blade in said Figs. 5 and 6 is that denoted by 3. These couplers are advantageously of insulating material, such as fiber. Each is preferably flat and comprises a shank as 17 and a hook as 18, the shank being united in some convenient manner as by a rivet 19 with its individual connector at some suitable point which may be at or near the rupturing portion thereof. It is not essential that the rivets 19 should rigidly unite the couplers 15 and 16 with the connectors 3 and 4, although this is desirable where the hook arrangement of the coupler is used, because this hook arrangement provides for individual movement of the connectors. In other words I provide broadly for the mechanical connection of the connectors with the actuator, and I provide for a certain amount of individual or free movement of each of the connectors or switching members in a direction lateral or sidewise of their opening or closing movement. This particular action I secure in the present case by providing for a free or loose connection between the actuator and the hook portion 18 of the couplers. It will be noted that the body or operating portion 13 of the bail part of the actuator 8 fits loosely in the open slots 20 of the hook portions 18 of the two couplers 15 and 16, by reason of which, the two connectors can individually move laterally or in a direction crosswise or transverse of their opening and closing movements. In the present showing the connectors are rigidly connected with the couplers and the couplers are loosely connected with the actuator, but clearly this condition could be reversed, because as will be understood, the invention does not concern itself with any detail, although the construction I have particularly described is advantageous. In some cases both connections might be loose, so long as each coupler is held at all times in proper mechanical operating relationship with the actuator and the respective switching member. In Fig. 1 the switch there shown is in the closed circuited position. To

open the switch the handle or manipulating portion 10 will be grasped and pulled down to the position shown for instance at the right in Fig. 2, this through the intermediate parts causing the movement of the connectors 3 and 4 from between the lips of the rupturing contacts 7. To close the switch the action described is reversed, and owing to the peculiar connection between the two connectors 3 and 4 and the actuator, the said connectors or switching members individually automatically and precisely aline themselves when they enter between the lips of said two rupturing contacts 7.

It is desirable that means of a positive nature should be provided for arresting the actuator when the switch has been opened or after the actuator has made a predetermined movement. It is also desirable where the switch serves for certain purposes, to positively lock it in the open position and to maintain this open circuited locked position of the switch. This latter point is of particular utility when the switch is incased in a box, cabinet or casing which may be sealed, so that after having been latched or locked in the open circuited position, access thereto is prevented, due to said sealing of the cabinet or housing in which it is incased, and thus the open circuit condition of the switch may be maintained until changed by authorized persons or until the seal is broken.

As will be understood there is preferably stop means and locking means, and although these may be entirely separate and distinct, I prefer as a matter of simplicity and reduction in cost of manufacture, to provide them on the same member, this member as a consequence serving a dual function, that is as a means for locking the switch in a definite position and also as a stop for arresting the motion of the switch in a predetermined direction. In the present case this locker is a lock-off device which is a desirable construction, but to which I am in no sense restricted. There is another point to which I wish to direct attention and that is the fact that I provide a locker for positively holding a switch in a certain position in conjunction with a sealable cover or equivalent sealable member for holding this locker in its switch-locking relation whatever that may be. A member such as meets these two conditions in a satisfactory way is that denoted by 25. This stop and locker member 25 as shown is in the form of a practically flat plate pivoted for example as at 26 to one of the side walls of the body of the cabinet or box 12 interiorly thereof. As shown the cover 27 of the cabinet or box 12 is of pivoted or hinged type which is a common form in this art. This combined locking and stop member 25 is constructed as illustrated with two laterally extending tongues or fingers 28 and 29 at practically right angles to the body of the member 25 which as will be understood swings in the plane of the inner face of its supporting side walls. These tongues or fingers 28 and 29 present jointly the active or locking portion of the part 25 the space between them receiving the adjacent side of the bail-like portion 9 of the actuator 8 when the switch is to be locked in the predetermined position which in the present case is the open circuited one. One of the tongues or fingers 28 and 29, the tongue 29 in the present case acting for this purpose, presents a suitable stop for arresting the motion of the switch when being moved to the open position, and this is accomplished by the adjacent side of the bail-like parts 9 engaging or abutting against the finger 29 when the switch has been given the predetermined opening movement as shown for instance in the lower dotted line position in Fig. 2 wherein the bail-like part has encountered said finger 29 to have the movement of the actuator arrested. It will be understood at this time of course, that the part 25 is functioning merely to arrest or stop the switch after the same has completed a predetermined opening movement. One of the edges as the edge 30 of the part 25 cooperates in the constriction shown with the cover 27 to maintain said part 25 in a fixed position whereby it can exercise the two functions. This edge 30, as illustrated is straight, although this may not always be necessary. It is fashioned thus in the present case to coact with the similarly formed adjacent inner surface of the cover 27 when the latter is closed as shown for instance in Figs. 2 and 3, at which point said edge or face 30 is contiguous to the inner surface of the cover, so that the latter will act as an effective means to prevent movement of the part 25 and thus maintain the latter in position to serve either of the functions stated. It will be clear, therefore, that before the part 25 can be operated, it is necessary that the cover 27 be opened. I have thus far described in detail merely the arresting or stopping effect of the part 25. It will be assumed that it is desired to lock the switch in a predetermined position as shown the open position. In this event, it will be necessary to open the cover 27 assumed to be sealed, and naturally the seal will have to be cut. When the seal is ruptured, the cover will be opened as shown partly in Fig. 4. When the cover is opened, the part 25 will be swung forwardly on its axis to carry the finger 29 free of the path of opening movement of the adjacent side of the bail-like part 9. The switch may be now opened, and when it is moved to the requisite extent or the relation it should occupy to be locked in said open relation, the member or plate 25 is swung to its original position, so that the fingers 28 and 29 will be

caused to straddle or embrace the adjacent side of the bail-like part 9 as shown in Fig. 3. When this is done the cover will be closed and sealed as by the seal denoted in a general way by 35. It will be seen on inspection of Figs. 2, 3 and 4 that the center of the movement of the member 25 is situated between the ends of the edge or face 30, the consequence being that when the cover 27 is closed swinging movement of said part 25 in either direction is positively prevented by the cover. This point is further accented in Fig. 4 wherein the cover is shown as partly opened and which indicates that this action or something of an equivalent character must be taken before the position of the part 25 can be changed.

Attention is directed to the peculiar construction of my locker which in this instance also serves as a stop, by reason of which it is possible to properly arrange the parts in the locked relation and also to at all times provide means for the stopping or arresting of the switch movement whether the cover is closed or open. This is accomplished by reason of the locker with its stopping functioning being independent in action of the cover.

What I claim is:

1. An electric switch comprising a box, a switching member in the box, an actuator for the switching member, accessible exteriorily of the box, a locker in the box for locking the switching member in a predetermined position, the box having a cover and the locker being inaccessible when the cover is closed and supported independently of the cover, and means for preventing switch releasing movement of the locker as long as the cover is closed.

2. A switch comprising a box and its cover, a switching member in the box, an actuator for the switching member accessible exteriorly of the box, a locker for locking the switching member in predetermined position, said locker being inaccessible when the cover of the box is closed and said cover when closed holding said locker in its operative position, the locker having a movement independent of the movement of the cover.

3. A switch comprising a box, a switching member within the box, an actuator for the switching member accessible exteriorly of the box and whereby said switching member may be moved to open or closed circuit positions, a locker within the box settable to lock the switching member and its actuator in predetermined position, said locker being mounted for movement independent of the cover and settable independently of the cover, the cover when in the closed position holding said locker in set position.

4. In an electric switch a box, a switching member in the box provided with an actuator therefor, a locker in the box for locking the switching member in a predetermined position, the box having a cover, the locker being movable to switch-member locking position when the cover is open, and the cover when closed holding the locker in said locking position.

5. A switch comprising a box and its cover, a movable switching member within the box, an actuator for the switching member supported by the box and accessible exteriorly thereof, a locker supported by the box and independently of the cover, said locker being movable to lock the actuator in predetermined position, the locker being positioned to be held in set relation when said cover is closed.

6. An electric switch comprising a switching member and an actuator for the switching member, and an element provided with means to coact directly with the actuator to lock the switching member in a predetermined position and also directly cooperative with the actuator to stop the opening movement of the actuator at a predetermined point.

7. The combination with an electric switch including a movable switching member and its actuator, of a unitary element dual-functioning for locking the switch in predetermined position and for arresting the movement of the switch at a predetermined point.

8. An electric switch comprising a switching member, an element in cooperative relation with the switching member and provided with means to enable said element to function either for switch locking or switch-movement arresting relations, said element occupying the same position when in said two relations.

9. In an electric switch, a box and its cover, a switching element and an exteriorly accessible actuator, and an element supported within the box and settable to a single position, the element being supported independently of the cover but cooperative with said cover so that when said cover is closed the element is held in set position, said element being provided with means when in said set position to serve for locking or arresting the movement of the switching member and its actuator.

10. In an electric switch a box, a switching member in the box, an actuator supported by the box and accessible externally thereof, for operating the switching member, a locker supported in the box and provided with means to engage the actuator when the switch is open to maintain said relation, the box having a cover, the locker having a movement independently of the cover and the cover when closed holding the locker in position to maintain the switch open.

11. In an electric switch a box, a [illegible]

...ing member within the box, a switch control operating actuator supported by ...ible exteriorly of the box, a combined lock off and stop element supported by ...inside of the box but independently of the cover, said combined element having means to hold the actuator in the off position and also to arrest the movement of said actuator dependent upon the setting of said combined element with relation to said actuator.

12. A switch comprising a plurality of switching members, a switch operating actuator, and connections between the switching members and the actuator for causing simultaneous opening and closing movements of the switching members and at the same time permitting individual and independent movements thereof, the switching members and the actuator being supported for movement independently of each other.

13. A switch comprising a plurality of switching members, a switch operating actuator, couplers uniting each individual switching member with the actuator for individual lateral movement of the switching members with relation to the actuator, the actuator and the switching members being supported independently of each other.

14. In an electric switch a plurality of independently supported switching members each having a coöperative stationary rupturing portion contact, a switch operating actuator, and a coupler directly individually connecting a switching member with the switch operating actuator so as to permit the switching member when moved into and out of engagement with its rupture portion contact to aline and position itself for free and unhindered movement into and out of said contact, the switching members and the actuator being supported independently of each other.

15. In an electric switch a plurality of movable switching members each being independently supported and coöperative with a rupture portion stationary contact and being also provided with an individual coupler for mechanical association of said switching element with a switch operating actuator in such a manner that each individual switching member while movable into or out of engagement with said stationary contact by the actuator is free to properly aline and seat itself into said contact when so moved, the switching members and the actuator being supported independently of each other.

16. In an electric switch a plurality of independently pivotally supported switching members, each coöperative with its respective rupturing portion stationary contact, a switch operating actuator pivotally supported substantially in alinement with the pivotal support of the switching members, each switching member being provided with its individual and independent coupler mechanically associating each of the respective switching members directly with the switch operating actuator whereby said switching members may be moved by said actuator into and out of engagement with said stationary contact by direct connection with said actuator, the switching members and the actuator being supported independently of each other.

17. In an electric switch a plurality of independently pivotally mounted switching members each coöperative with its respective rupturing portion stationary contacts and provided with its individual coupler, each of the switching members and their respective associated couplers being mechanically independent and disconnected, and a switch operating actuator pivotally supported substantially in alinement with the pivotal supports of said switching members and formed for mechanical association with said couplers for thus by means of the actuator moving in unison the plurality of individually supported and mechanically disassociated switching members into and out of engagement with their respective stationary contacts, the switching members and the actuator being supported independently of each other.

18. In an electric switch a plurality of individually pivotally supported switching members, each coöperative with its respective stationary rupture portion contact and each provided with its individual coupler associated therewith at a distance from the pivotal point, and a switch operating actuator pivotally supported independently of the switching elements but substantially coaxial with the pivotal supports of said switching members, each of said couplers associated with its respective individual switching member being formed for engagement with said actuator and whereby said switching members are moved by said actuator in unison into and out of engagement with their respective stationary contacts, the individually independent switching members being otherwise except through said actuator entirely independent of each other.

19. In an electric switch a plurality of individually pivotally mounted switching members, each coöperative with its respective rupturing portion stationary contact and each provided with a separate and independent insulating coupler, and a switch operating actuator pivotally supported for movement approximately about the same axes as the switching members, said couplers and said actuator being adapted for mechanical engagement for thus by the movement of the actuator correspondingly moving the switching members, and the switching members being each entirely mechani-

cally disassociated and independent of each other excepting through said engagement with said actuator directly through said couplers.

20. In an electric switch a plurality of individually pivotally supported switching members and their coöperative rupture portion stationary contacts, each of said switching members being individually provided with an insulating coupler joined thereto by a fixed connection and each of said couplers being provided with a portion for individually loosely engaging each of said switching members with an actuator.

21. In an electric switch, a plurality of individually pivotally su orted switching members and their resp ive coöperative rupture portion stationar ntacts, a swinging actuator approximate oaxial with the switching members, indiv al couplers associated mechanically by a fixed connection with each switching member independently of any other, each of said couplers having a portion adapted for engagement with the actuator and whereby said switching members may be moved in unison by said actuator, each independently through its respective coupler, said engaging connection between each of said individual couplers and said actuator providing for lateral movement of each individual switching member as it enters or leaves its respective rupturing portion contact.

In testimony whereof I affix my signature in the presence of two witnesses.

JOSEPH SACHS.

Witnesses:
L. L. MARKEL,
HEATH SU[illegible]LAND.

DISCLAIMER.

1,292,081.—*Joseph Sachs*, Hartford, Conn. ELECTRIC SWITCH. Patent dated January 21, 1919. Disclaimer filed August 1, 1928, by the patentee, *Colts Patent Fire Arms Manufacturing Co.*, a Corporation, consenting to and ratifying this disclaimer "in so far as its interest in the aforesaid patent may appear."

Hereby enters this disclaimer as follows:

"He hereby disclaims all switches of the character described in claims 12, 13, 14, 15, 16, 17, 18, 19, 20, and 21 except those wherein the actuator extends transversely of the switching members and wherein each connection or coupler between a switching member and the actuator is rigidly and fixedly secured to its switching member and is provided with an open slot for receiving the actuator."

[*Official Gazette August 21, 1928.*]

600

PLAINTIFF'S EXHIBIT No. 71

484

J. SACHS.

ELECTRIC SERVICE AND METER TESTING SYSTEM.

APPLICATION FILED MAY 11, 19[illegible].

1,301,175.

Patented Apr. 22, 1919.

4 SHEETS—SHEET [illegible].

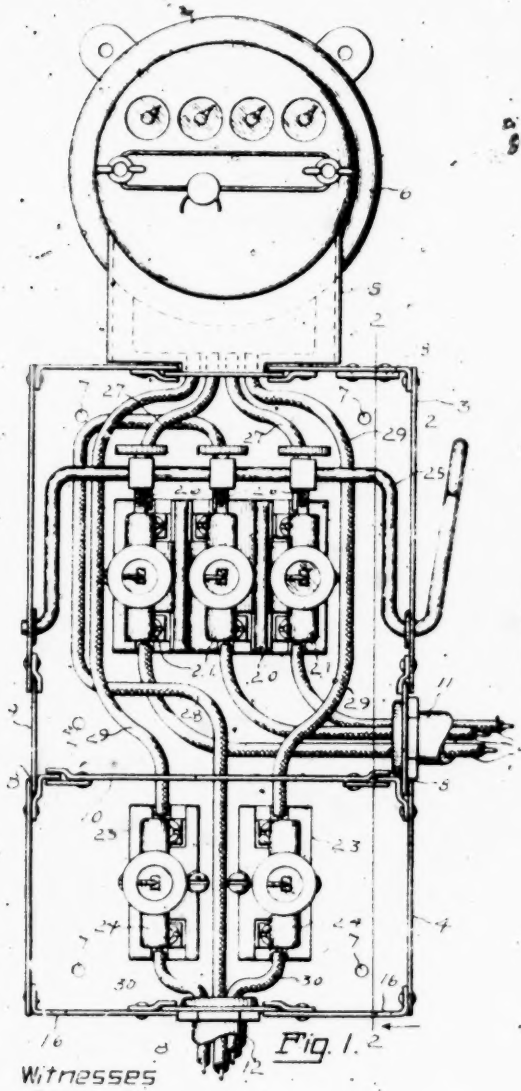


Fig. 1.

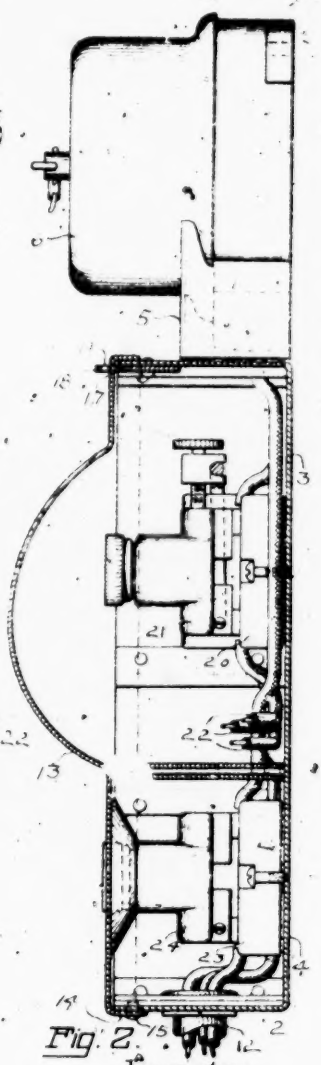


Fig. 2.

Witnesses

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485

J. SACHS.

ELECTRIC SERVICE AND METER BOSTER SYSTEM.

APPLICATION FILED MAY 17, 1917.

1,301,175.

Patented Apr. 22, 1919.

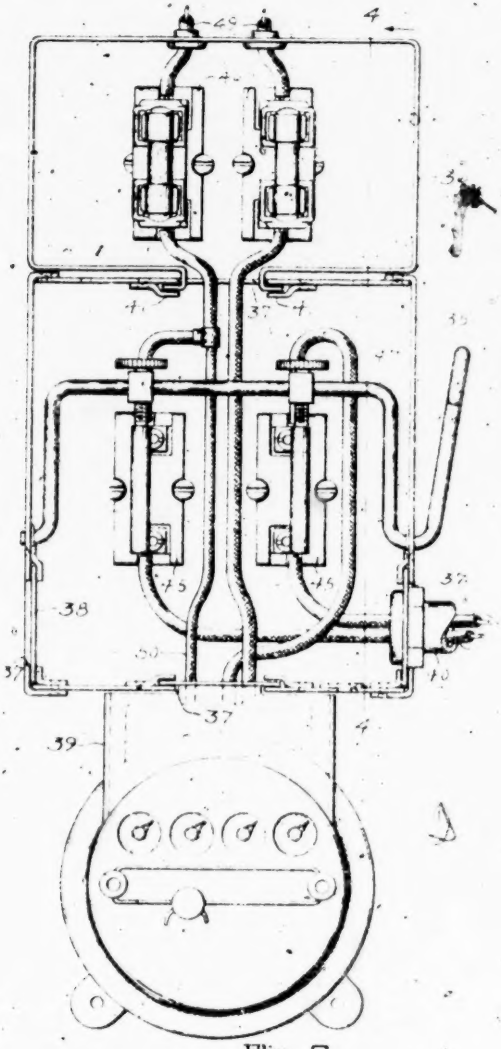

Fig. 3.

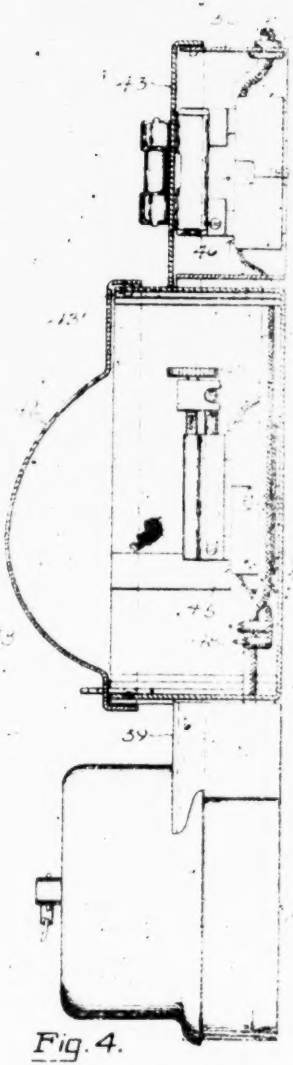

Fig. 4.

Witnesses

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J. SACHS.

ELECTRIC SERVICE AND METER TESTING SYSTEM.

APPLICATION FILED MAY 11, 1915.

1,301,175. Patented Apr. 22, 1919.

4 SHEETS-SHEET 3

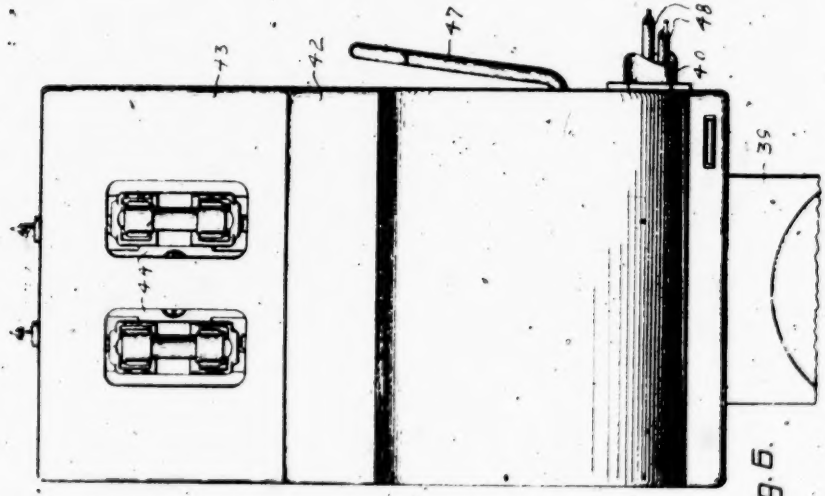

Fig. 6.

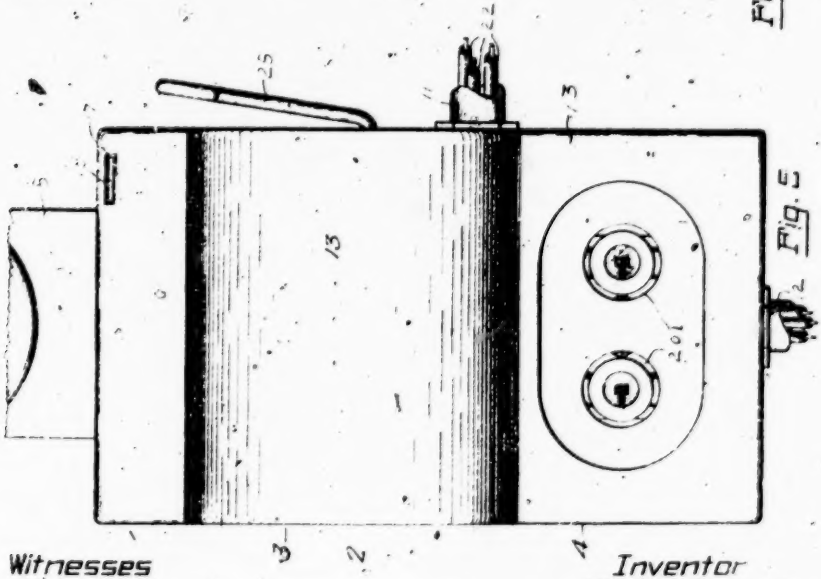

Fig. 5

Witnesses
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487

J. SACHS.

ELECTRIC SERVICE AND METER TESTING SYSTEM.

APPLICATION FILED MAY 11, 1918.

1,301,175.

Patented Apr. 22, 1919.

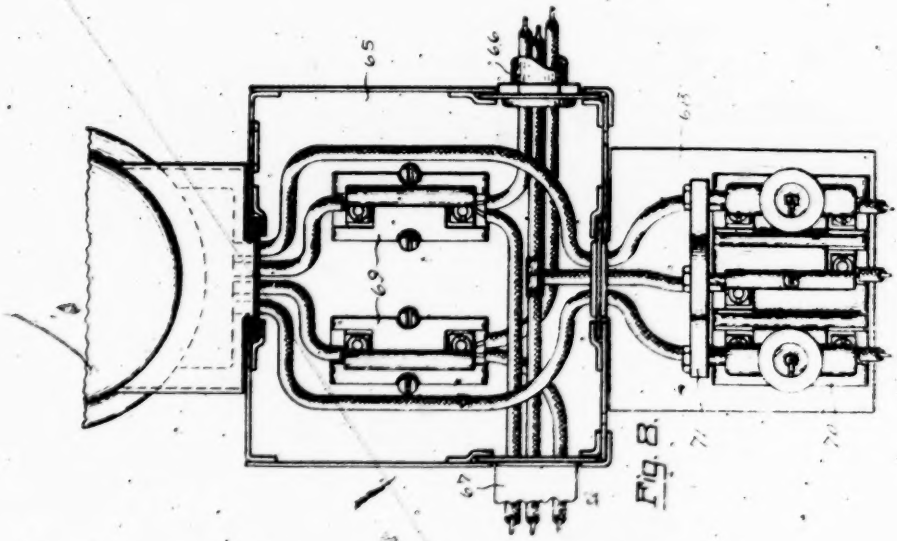

Fig. 8.

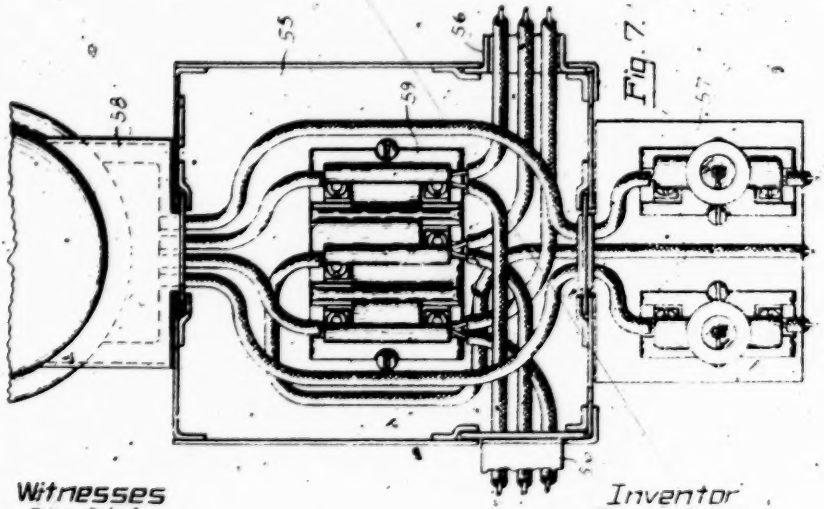

Fig. 7.

Witnesses
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Frank J. Wolter

Inventor
Joseph Sachs.
By Hazel & Thomas
Attorney

UNITED STATES PATENT OFFICE.

JOSEPH SACHS, OF HARTFORD, CONNECTICUT.

ELECTRIC SERVICE AND METER TESTING SYSTEM.

1,301,175. Specification of Letters Patent. Patented Apr. 22, 1919.

Application filed May 11, 1915. Serial No. 27,360.

To all whom it may concern:

Be it known that I, JOSEPH SACHS, a citizen of the United States, residing at Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Electric Service and Meter Testing Systems, of which the following is a specification.

This invention relates to what I shall for convenience term an electric service and meter testing system. In Letters Patent No. 1,211,629, for electric switches and meter testing systems, issued to me January 9, 1917, I have shown, described and claimed an organization involving the use of what I denoted in that application as "base block units." By the use of these units with the association therewith of such element or elements as may be requisite I can produce various differently functioning appliances, such as cut outs, switches or meter testing and service connection blocks, which are merely three of many different examples. In the present case I provide a system in which I use unit base blocks; by this I do not mean to imply that it is necessary to employ the identical unit base blocks of my prior application, although this is what I prefer to do. In using these base block units in such combination as the exigencies of the particular case may require, I so dispose them in relation to one another and also in relation to certain cooperative elements if present, to produce a complete service and meter testing appliance functioning to properly connect the service with the customer's load and the installed meter, while at the same time serving if desired, as a circuit controlling switch for that particular service and also as a meter testing service connection block, so that when necessary or desirable the installed meter can be easily tested in any one of several different ways one of which has been already described in my prior patent already identified.

In the particular invention here under consideration I have so combined such of the base block units and other cooperative elements as may be necessary in such a manner that there is provided a service connection appliance, a part of which is located, placed or disposed so as to be accessible only to the authorized person, and which for instance, may be accomplished by inclosing this part under lock or seal. Another part of the appliance is so located, placed or disposed as to be readily accessible at all times.

Where an electric service company installs a service connection it is desirable that means be provided to seal or lock up against unauthorized tampering, certain connection parts of the service connection in order that there will be no theft of current or unauthorized connection to the service before the current has been passed through the meter and properly measured. Consequently there have been produced devices, or appliances placed in housings or casings which are suitably associated and related with the installed meter, so that the service wires connected to the service connection device and extending to the meter are properly protected for the purpose described. As an instance of such appliances, I may refer to my Patent No. 1,245,036 of October 30, 1917, for protective casing for electric service connection and meter device, in which is shown a form of protective housing or casing for such service devices. In my Patent No. 1,211,629, there are shown other forms of protective casings or housings for this purpose operatively related with these connection, switching and meter testing appliances. In such devices or appliances as have just been referred to, the connection parts, elements or members of the complete appliance on the service side and on the load side of the meter are both shown as incased in the same compartment or chamber of the housing. Consequently while the protective requirements are fulfilled in such a disposition of the service connection parts, members or elements of the appliance, it is possible only, however, to reach any particular part of the connection devices, when it may be necessary, by unlocking or breaking the seal of the box, and this should only be done by authorized persons. Therefore, in the case where such connection appliances are equipped on either the load or the service side with protective devices such as for instance fuses, the blowing of a fuse so incased and sealed in a housing would disconnect the load from the service until someone authorized opened the box and renewed the fuse. Consequently the consumer would be without current during that period.

Again in such just referred to arrangements the installation of the complete service connection appliance with its housing

is usually considered as a unit. From this aspect it is common for the electric service company to install the complete appliance including its housing and connection devices on both the service and the load end and including such switching and other cooperative elements as may be desired. Electric service companies are naturally desirous of reducing the investment in making each particular service connection, and consequently are desirous of in some way distributing the cost in making the service connection, so that the expense of purchasing and installing the necessary service connection appliances does not fall entirely upon them. This condition is met in the present invention by the use of my already referred to base block units which are so disposed that one or more of these units may be installed and placed by the electric service company on what may be called the service side, and which electric service company installed unit or units may be incased or housed and locked or sealed against tampering or manipulation by any one except authorized representatives of the company. Another or other base block unit or units may be installed by the consumer or the contractor on what may be called the load side in such relative position, placing or location to the first above referred to base block units that the load side unit or units and the service side unit or units may be coöperatively manipulated for testing, switching or other purposes in the manner already shown, discussed and described in the several copending applications referred to. The load side unit or units may be placed in close proximity if desired, to the service side unit or units, and may be incased or unincased. If incased the casing may completely surround the load side unit or units, or it may only partially surround the load side unit or units, but in either case if a casing for these units is provided, the renewable element such as the fuses of the load unit or units, is made readily accessible so that this part of the load side unit or units can be reached and manipulated by the consumer. It will, however, be understood that it is not essential that the consumer should be able to manipulate any other parts of the load side unit or units, and if desired the casing may be of such design so that while permitting the manipulation of the fuse parts of the load side unit or units, it prevents tampering or manipulation of other parts of the unit.

Whether a casing is provided for the load side unit or units or whether these units are unincased, it is desirable that means be provided for holding them in a definite relation with the service side unit or units, although it will be understood that such means are not imperatively essential.

It will be clear that with such a division of obligation, a very excellent result is brought about, because it is now possible for the electric service company to install its service side connection parts and for the consumer or contractor to install his load side parts, elements or members of the service connection appliance. Notwithstanding such division of the expense and the investment of the service connection there is yet a universality of relationship between the service side and the load side connection parts, members or devices, so that there may be associated with either side correlative elements such as for instance, switching operating devices, and furthermore the service and load side elements, parts or members, that is to say the base block unit or units on the respective sides are of such character and construction, as has already been shown and described in my prior Letters Patent No. 1,216,629, as to be susceptible for the ready, simple and expeditious connection therewith and thereto of testing appliances for the proper testing and checking up of the installed meter by the electric service company's representative or such others as may be duly authorized when necessary. In fact this functioning of the complete appliance for meter testing purposes is exactly as has already been shown and discussed for example in my Patent 1,211,629.

It may also be stated at this time that due to the universality of the disposition, mounting, placing or locating of my base blocks units with relation to each other, that it is possible to use what I have termed the main base block unit on either the service or the load side and the auxiliary base block unit or units on either the service or the load side. Furthermore it has been made clear, in my Patent No. 1,211,629, and also in my Patent 1,170,118, a switch operating element may be associated with either the main base block unit or with one or more of the auxiliary base block units or with auxiliary and main base block units in combined relationship with the switch operating element. Another feature of the present invention is that in coöperative relationship with the base block units I use a protective housing of advantageous form and construction, providing therein a compartment or chamber for the service side connection parts, elements or devices, and which chamber or compartment may be properly sealed and locked, and also provide for coöperative association with the aforesaid service side chamber or compartment means for carrying or mounting the load side devices, and which latter means may be in the form of a boxing or housing or merely a support, but in either case is preferably associable with the first aforesaid compartment or housing so as to be interchangeably placeable in relation thereto. I

may also state at this point that there may be associated with either the service or the load side parts or both, suitable fuses, or there may be switch operating elements on either or both sides. From the showing in the drawings hereinafter referred to, it will also be clear that I propose to make it possible for the interchangeable disposition or relationship to the what may be called service side compartment or chamber or housing of a meter adapter and the load side device supporting or inclosing means, so that the meter may be interchangeably placeable with the load side devices in relation to the main service side supporting compartment, chamber or housing.

In the drawings accompanying and forming part of the present specification, I have represented in detail several of the many different forms of embodiment of the invention. These will be set forth fully in the following description. It will be clear that I do not restrict myself to this construction; I may depart therefrom in many respects within the scope of the invention defined by the claims following said description.

Referring to said drawings:

Figure 1 is a face view of an electric service and meter testing appliance comprising my invention, both the service and the load side parts being incased or housed in a common two compartment box, the cover of which is removed, the meter being shown in place.

Fig. 2 is a longitudinal section on the line 2—2 of Fig. 1 looking in the direction of the arrow, the cover being in place.

Fig. 3 is a view corresponding to Fig. 1 of a different form of the appliance, this view illustrating the meter as being below the service side devices instead of above as in Fig. 1, the cover of the interchangeably associable boxes being off.

Fig. 4 is a longitudinal section on the line 4—4 of Fig. 3 looking in the direction of the arrow, the covers of the boxes being on.

Fig. 5 is a face view of the appliance shown in Figs. 1 and 2 with the cover on, the meter being broken away.

Fig. 6 is a similar view of the appliance represented in Figs. 3 and 4 with the cover on, and with the meter also broken away.

Figs. 7 and 8 are views corresponding to Figs. 1 and 3 of still further arrangements, the load side devices in both these forms of the appliance being unincased.

Like characters refer to like parts throughout the several views.

I provide a suitable support. This support may as will be inferred, vary decidedly in construction, depending upon the arrangement of the various parts of the appliance. It is important that it should have a section, compartment or chamber to receive the service side devices, and as I have already noted, this compartment is maintained under lock and key or sealed or is otherwise of such nature as to prevent unauthorized tampering with any of the parts inclosed thereby. The support may also have as a part thereof means on which may be mounted the devices of the load side of the appliance. As will be gathered, there are load side devices which coöperate with the service side devices in any individual installation. These load side devices may be mounted in any desirable way. I prefer that the support to which I have alluded be provided with means in or on which the same may be mounted. I provide preferably a two section support, one a service side chamber or compartment, and the other of which presents the load side section, chamber or compartment. These two sections or compartments when present may have a cover or lid, or each may have its own cover or lid. When the load side devices are not incased and when the support is provided with means for carrying them, this carrying means may be of any suitable character. There may be instances as will hereinafter more particularly appear where the support may be of sectional type, and in this event the sections are interchangeable. That is to say the complete support will always comprise a sealed or locked service side portion, but the load side portion of the support, detachably and interchangeably related to the service side of the support, may be of many different forms. It may be in the form of a casing or housing made so as to permit of the accessibility of the load side connection devices therein, or it may be in the form of a mere backing or connectible plate supporting the load side devices but leaving them entirely exposed.

Referring first to Figs. 1, 2, and 5, the support represented in these views is denoted in a general way by 2 and is in the form of a boxing, and by boxing I do not mean a box but a structure which has one or more sections or compartments or which has a single section or compartment. This support or boxing 2 comprises a main, primary or service side box or casing 3, and an auxiliary, secondary or load side box or casing 4, the interior of the latter casing 3 constituting a convenient compartment or chamber to receive the service side devices while the interior of the box or casing 4 presents a suitable chamber or compartment for receiving the load side devices. A meter adapter or extension is denoted by 5 and associated with it is the meter 6. The support or boxing 2 is attached to a suitable backing or foundation which may be a wall or board, and to so mount it, the back or the backs of its sections may be perforated as at 7 to receive suitable fastenings as screws. The backing of the boxing 2 in both

the main or service side and the auxiliary or load side section is provided with suitable means for receiving fastenings to hold in place the necessary service and load side base block units. The boxing 2 has the backing or bottom plate referred to and extending outwardly from each side or edge thereof, is a wall, so that there is formed as shown a suitably shaped walled body. Each of the walls is provided with slots or apertures as 8 adapted to be closed by suitable slides as 9. These slides may be blank or perforated in any desired fashion, and they may serve alone or for attaching thereto certain other members such as for instance the meter adapter 5 which as shown is connected to and forms part of the slide in the slot or aperture of the upper wall of the boxing. The boxing is divided into two sections 3 and 4 by the removable partition 10. This partition being suitably apertured to permit of the passage of the necessary wires from one section to the other. The slide 9 on the right is suitably connected to the service conduit 11, while the slide 9 on the lower wall of the boxing is connected with the load conduit 12. As will be clear the conduit pipe 11 may be connected to either side of the boxing and as will also be clear, the slide 9 in the left wall of the boxing may also have connected therewith suitable ducts or wireways or be otherwise provided with means to permit of the carrying from the section 3 of the boxing of such wires as may be desired. While I have shown only four means for receiving the slides, it will be understood that there may be any number of such means. The entire boxing is provided with a single cover as 13 which as may be noted in passing is common to both sections 3 and 4. The cover has the lip 14 entirely around its edge. At the lower end of the cover, the lip is provided with pins as 15 adapted to enter holes or apertures as 16 in the lower wall of the body of the boxing. The cover at or near its upper end has an aperture 17 through which passes the seal piece 18 when the cover is in place. The seal piece is fastened to the upper wall of the body of the boxing and the end projecting exteriorly of the cover when in place has openings as 19 for receiving a seal or lock. The lower portion of the cover 13 has means such as an opening or openings by which access may be conveniently had to the interior of the load side section 4. In this particular instance, this is to provide accessibility to a fuse or fuses on the load side devices. As represented the cover or lid 13 has duplicate openings 201 by which these fuses or their equivalents can be reached.

As will be obvious from the remarks already made, the appliance comprises a plurality of base block units separately mounted, and these units may be either of what I have denominated in my Patent No. 1,211,629, as main base block units or auxiliary base block units. In a given installation there may be one or more main base block units separately mounted, operatively associated with one or more auxiliary base block units, or there may be one or more auxiliary base block units operatively associated with each other, or there may be one or more main base block units operatively associated with each other. In other words, I wish to make it clear, that I do not limit myself to any particular number or kind of base block units than is requisite to present an operative appliance functioning in the desired purpose. What I have denoted a main base block unit comprises as a preference, a plurality of pairs of contacts or their equivalents and their associated connectors, whereas what I have termed an auxiliary base block unit consists preferably merely of a pair of contacts or analogous parts and coacting connector, and as will be inferred this connector may be any one of a variety of styles. For illustration, it may be plain or on the other hand it may be fused, and if fused may in turn carry any one of different kinds of fuses. As has been already explained in my Patent 1,211,629, certain particular arrangements of the main and auxiliary base block units have been found satisfactory. For instance, as stated in the application just mentioned, a main base block unit provided with three pairs of contacts and their associated connectors. I also prefer to utilize merely but a single pair of contacts and a cooperating connector in an auxiliary base block unit.

It will be apparent that in an appliance there must necessarily be one base block unit, at least, which is normally inaccessible and at least another base block unit which is accessible or at least the fuses or equivalent devices of which can be reached for replacement. In some apparatus one or more of these base block units may be inaccessible, whereas one or more of their fuses or equivalent parts will be accessible.

Referring now again to Figs. 1 and 2, I denote in a general way by the numeral 20 a main base block unit. This unit has an insulating body, for instance of porcelain equipped preferably with three pairs of contacts and wire connecting members. Associated with each pair of contacts is a connector as 21 constituting a part of the unit in question. This is a quite brief description of a main base block unit which is suited to my purposes and which closely resembles one of the main base block units disclosed in said Patent 1,211,629. The connectors 21 are all fused with plug fuses. This main base block unit 20 as represented is mounted in the main casing or housing 3 and being

connected on the service side of the meter and to the service wires 22 constitutes the service side unit. This main base block unit which as arranged serves the purpose of a service side unit is shown mounted in the service side or main chamber, compartment or box 3 of the boxing 2 and may be held in place by screws or otherwise. It will be clear that the backing or bottom plate is suitably perforated with threaded holes to receive the fastening means to hold down the main base block or such of the auxiliary base block units as may be desired for mounting in said main chamber.

In the load side compartment, box or casing 4 are mounted the auxiliary base block unit means shown in the particular construction under consideration as comprising two of such auxiliary base block units 23 fastened in place to the back or equivalent part of said chamber 4 in such manner that one or more of such units can be dismounted, and if occasion requires, a main base block unit substituted therefor. Screws, as already noted present a simple and convenient means of holding the auxiliary base block units removably in position. Each base block unit 23 is provided with a pair of contacts on the insulating body thereof the contacts as is the custom being provided with wire connecting means. With each pair of contacts is associated a connector 24 which in the construction is of the same character as the connectors 21, although as will be obvious any other suitable connector might be employed in lieu thereof.

The main base block unit may as illustrated, have associated therewith a switch operating element of suitable nature. This as will be understood may be any one of several kinds. That shown is denoted in a general way by 25 and is of the externally operable type being in construction substantially like that shown and described in the first application hereinbefore mentioned. This switch operating element 25 is equipped with coupling pins 26 which can be connected to or disconnected from, at will, one or more of the connectors 21, and when the connectors are coupled to the switch operating element 25, they can be operated and serve as circuit controlling switching elements. In the particular arrangement shown each of the three connectors is coupled to the switch operating element, and consequently when so coupled and operatively associated with the switch operating element constitutes a three-pole or three-wire switch.

The particular service installation shown in Figs. 1 and 2 is a three-wire installation, the meter being a two-coil, three-wire meter, each coil being in one of the outside legs of a three-wire circuit. The three service wires 22 enter the main chamber or compartment 3 through the service pipe or conduit 11, being connected to the service end of each of the three pairs of connection and contact members mounted on the main base block unit 20. The circuit from each service wire is continued through its respective connector to the meter end connection and contact member of that particular pair. The wires of the circuit now continue from the main base block units and extend to the meter and load. The two outside wires 27 of the circuit, each extending and connected to one terminal of each of the coils of the meter respectively, may be called the meter wires, the wire 28 extending from the load end contact and connection member of the base block unit is a load wire and passes directly to the load. There is no tap from the neutral wire to the meter, because the potential coil of the meter is inside connected. Extending from the opposite terminals of each of the two meter coils are the meter wires 29, and these at their other ends are connected to the meter end connection and contact member of each of the two auxiliary base block units 23. The circuit now extends to the load through each of the connectors 24 to the load end connection and contact members of the auxiliary base block units 23 at which point the two outside load wires 30 are connected.

I have shown in a number of prior patents how an appliance constructed as hereinbefore may be utilized in meter testing and specifically I might mention Patent No. 1,170,112 of February 1, 1916, and also Patent No. 1,170,139 of February 1, 1916. It will be understood in meter testing that the so-called flexible bridge or by-pass system of testing devices will be preferably used, such as has been shown and described in said Patent 1,170,112. In by-passing it will be understood that the cable or flexible wire of the by-pass will be of sufficient length so as to permit of its connection across from one of the outside connectors of the main base block unit to the correlative connector of one of the auxiliary base block units. When this is done one or both of the connectors may be opened up so as to free its cooperative connection and contact member for testing purposes, that is for the reception or connection therewith of proper testing plugs of the main testing circuit or such other testing devices as may be necessary. The manner of connecting to the other contacts and parts of the main and auxiliary base block units need not be here described, as this will be practically identical with that already discussed in the hereinbefore mentioned applications. It is obvious when testing that the cover or lid 13 must be removed in order to permit of application of the necessary testing devices. I also might note that the openings or apertures 201 are op-

posite the fuses of the connectors 24 so that if either of these fuses be blown, it can be easily removed. However, it will be noted that the fuses on the main base block unit are inaccessible as are also all of the other connection and contact parts and devices within the main chamber 3. The fuses on the main base block unit are on the service side of the meter in each of the poles or wires of the circuit. The fuses on the auxiliary base block units are on the load side of the meter in the two outside poles or wires of the circuit. It will, therefore, be desirable that the fuses on the main base block unit be of greater capacity than the fuses on the auxiliary base block units, it being intended that ordinary abnormal conditions should permit of fuse replacements by the consumer but extremely abnormal conditions should require the attention of the service company's representative. Consequently when the abnormal condition is so severe that the fuses on the service side of the meter blow as well as the fuses on the load side, then the installation requires the attention of the company's representative.

In Figs. 3, 4 and 6 is shown another form of boxing as well as base block unit arrangement. In this particular showing the support is of different character from that already described. It has detachably connected sections, and as will be inferred, these may be of any suitable kind. For example and as illustrated they consist of boxes or castings separably connected in such way that their relative positions may be varied, although as a matter of fact I prefer that the main section or box be permanently fastened in place and that the auxiliary section or box of the complete support can be removed from the main box or support to change its position with relation thereto. The main section or box is designated by 35 and the auxiliary section or box by 36. The main section or box 35 of the complete support has a back or bottom plate provided with suitable holes to receive fastening means such as screws, so that it may be securely held to a foundation. Extending outwardly from the back plate are the four walls, each wall having a slot or aperture 37, and these walls are equipped with means for receiving slides as 38 or other parts such as the meter adapter 39 or auxiliary box or section 36 which can thus be connected with the main section or box 35. As heretofore one of the slides is fitted to the end of a service pipe 40 which is shown entering the main section through the right hand wall, but as will be understood it may enter at any other point. The particular arrangement of boxing with the two detachable sections as shown is of particular utility and advantage in permitting the interchangeable placing of the meter either above or below the main section or box 35. The manner in which this can be accomplished is due to the fact that the slide receiving apertures or slots in the main box walls are all alike. Consequently the meter adapter 39 may be placed as shown in the lower wall, or when the auxiliary section is dismounted, it can be substituted for the latter, and when said meter adapter is so placed in connection with the upper wall, then the auxiliary section or box 36 will be placed in connection with the lower wall. It will be noted that when the auxiliary box or section 36 or the meter adapter 39 are attached to either the upper or lower wall of the main section 35, they are securely held in place as are also the slides 38 due to the presence of the overhanging lips 41 (Fig. 3) of the slide holding means. Each of the two sections 35 and 36 has its individual cover, the cover for the main section 35 being denoted by 42 and the cover for the auxiliary section 36 being denoted by 43. The cover 42 is mounted and locked and sealed exactly like the cover 13. The cover 43 is practically similarly mounted excepting that at the end where it abuts the main section 35 there is a projection 43' from the cover 43 extending outwardly and inside the lip of the main cover 42, it being held in position and locked on the auxiliary section or box 36 when the main cover is locked and sealed in the manner described. In the present construction the cover 43 is not normally openable, although access may be had to the fuses of the connectors associated with the auxiliary section or box 36 as will now appear. Openings 44 in said cover 43 are provided through which the fuses of each of the base block units located in the auxiliary box or section 36 project.

The particular installation of Figs. 3, 4 and 6 is a two-wire installation. The base block units used in both the main and service side section or box 35 and the auxiliary or load side section or box 36 of the complete support are all of the auxiliary base block unit type. On the service side in each of the two wires of the circuit, there is an auxiliary base block unit denoted in a general way by 45, and these may, therefore, be called the service side base block units, although they are of the auxiliary type. On the load side of each of the two wires of the circuit, there is an auxiliary base block unit denoted in a general way by 46, and these may be called the load side base block units. They are also of the auxiliary base block unit type. It will be noted that the service side base block units are unfused, while the load side base block units have their connectors provided with inclosed fuses which as shown extend through the openings or slots 44 to which I have already referred. Certainly as will be clear, from what has already been said, the service side base block

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units in the main box section or case 35 are inaccessible, while the fuses of the load side base block units are accessible and manipulable, although the connector itself of these units cannot very well be reached for manipulation or operation.

Associated with the base block units 45 on the service side is the switch operating element 47 connectible and disconnectible with the connectors of the aforesaid base block units in the manner already described. This switch operating element is of the exteriorly operable type, but instead of being provided with three connector coupling means has only two, so that when coupled with the connector elements of the base block units 45, a two-pole exteriorly operated switch is presented.

It will be unnecessary to follow out in detail the extension of the circuit from the service wires 48 through the service base block units, the meter coil and the load side base block units to the load wires 49. This circuit path is clearly shown in Fig. 3. The wire 50 is the potential tap from one side of the circuit to one side of the meter coil.

In Fig. 7 I have shown an organization consisting of a service connection appliance arranged for a banked installation. That is to say there are a number of consumers connected to the service, each of which consumers have their individual service connection and meter testing appliance. In such banked installations it is not always necessary that each consumer have a service switch. The support of the appliance shown in Fig. 7 is of the same interchangeably connectible character with its two separably connectible sections as that shown in Figs. 3, 4 and 6. The main section or box 55 is substantially like the main section or box 35 of the appliance of Fig 3 with the exception that it is not provided with means for supporting the switch operating element since no such element is used in this case. Also instead of a service pipe or conduit being connected to this main section or box 55, there is connected to each of the two side walls what may be called a trough, denoted in a general way by 56, the one on the left being shown with the cover on, and the one on the right with the cover off. These troughs are provided for connecting adjacent main sections like 55 or 35 or similarly arranged and correlative parts. The auxiliary section 57 is in the form of a plate provided with an outwardly extending portion connectible in slide-like form with the walls of the box in the manner shown and as already described in connection with the slides and similar parts of Figs. 3, 4 and 6. Due to this arrangement this auxiliary plate or section 57 may be connected either with the lower wall or section 55 as shown or when the meter adapter 58 is removed from the upper wall, this auxiliary section or plate 57 may be put in its place and the meter adapter then may be placed in connection with the lower wall. In the wall connected slide portion of the plate 57 there is provided means such as a perforated bushing to permit wires to extend from one section to another through the perforations in the bushings.

The particular subscriber's installation shown in Fig. 7 is a three-wire installation, but as has already been stated, there is no service switch. The meter is of the two coil, three wire type. The fuses instead of being on the service side are here shown as in the case of the showing of Figs. 3, 4 and 6 entirely on the load side. In this particular three-wire installation, a main base block unit 59 is shown installed in the main section or box 55 and is, therefore, the service side base block unit and is inaccessible due to the fact that the cover to this main section is sealed or locked, it being of the same construction as the cover 42 in Fig. 4. The base block units 60 on the load side are of the auxiliary base block unit type and are wholly exposed. There are only two auxiliary base block units used on this load side, the neutral wire passing through directly from the central or neutral parts of the main base block units on the service side.

In Fig. 8 there is shown an installation of the same character as that shown in Fig. 7 with the exception, however, that instead of in this particular case there being a trough on each side of the main section 65, there is a service pipe 66 connected to the right hand wall, while a trough 67 extends to another main section or similar device, adjacent thereto. As in the case of Fig. 7 the auxiliary section consists of the separably connectible plate or carrier 68. While this particular subscriber's installation is also a three-wire system, yet the arrangement of base units here shown is entirely different than the arrangement shown in Fig. 7. On the service side and located in the main section or box 65 are two unfused base block units 69 of the auxiliary base block unit type, one being connected in each of the two outside legs of the circuit. On the load side and mounted on the auxiliary section or plate 68 is a main base block unit 70 of the main base block unit type. This main base block unit 70 is equipped in its outside poles with fuses and the three connectors are shown coupled to a switch operating element 71 of the direct operating type. Each of the connectors is coupled to the switch operating element 71 by means of studs or pins, the central pin being held to the central connector by a screw or other convenient means practically as shown for instance in Fig. 1 and already described, so as to firmly associate the switch operating element 71 with the connectors and permit

of their operation collectively to perform the function of a three-pole circuit controlling switch, all as fully shown in Fig. 8. Each of the three connectors of the base block unit 70 on the load side is in the path of one of the wires of the circuit. It will be noted that the neutral wire of the circuit is not connected with any base block unit on the service side, it being directly tapped off and extending to the central or neutral element of the load side base block unit 70.

It will be seen from the showing of Fig. 8 that the switch instead of being on the service side is on the load side of the appliance, wholly accessible both as to its operation as a switch to open and close the circuit and also so far as concerns the manipulation and renewal of the fuses on the two outside legs of the base block unit 70. However, due to the fact that the cover on the main section or box 55 is sealed and locked in place as heretofore described, it being of the same construction as that used in connection with the appliance of Fig. 7 or Figs. 3 and 4, the base block units and connections on the service side are inaccessible, but the base block unit 70 on the load side with its fuses which functions as a circuit controlling switch is entirely accessible. Now to test the particular meter installed in conjunction with this installation of Figs. 8, it is certainly necessary to remove the cover of the main section 65, and it is also necessary to uncouple the switch operating element 71 from the three connectors of the base block load side unit 70. After this is done then the manipulation of the connectors on the load and the service side is generally the same as has been fully discussed heretofore and is now no doubt fully understood.

What I claim is:

1. In a device of the character described, circuit-controlling means connectible on the service side of an electric meter, circuit-controlling means connectible on the load side of said meter, a box for inaccessible inclosing the service side connectible means, the load side connectible means being accessible, and means cooperatively associated with said service and load side connectible means whereby the meter may be tested through the medium of said service and load side connectible means.

2. A device of the character described comprising a support having a service side portion and a load side portion, one of the portions being equipped with means for receiving an electric appurtenance and, the other portion being provided with means for receiving another electrical appurtenance, the device having means for normally preventing access to the part carried by the service side portion, and also having means to permit a meter test through the coöperation of said parts carried by the service side and the load side portions.

3. In a circuit-controlling and meter testing appurtenance, circuit-controlling means connectible respectively on the service and load side of an electric meter, a casing for inaccessible inclosing the service side connectible portion, the load side connectible portion being accessible, and means whereby said meter may be tested through the medium of said service and load side connectible means.

4. In a device of the class described comprising inaccessible circuit-controlling means connectible on the service side of an electric meter, accessible circuit-controlling means connectible in the load side of said meter and means in association with said service and load side devices for the connection therewith of meter-testing means and whereby said meter may be connected for testing through the medium of said service and load side means.

5. An appliance of the character described comprising a circuit-controlling unit connectible on the service side of an electric meter, another controlling unit connectible on the load side of the meter, means for the association with said service and load side units of testing appurtenances, a support for said units, means for normally inaccessibly incasing the service side unit and for leaving a part of the load side unit accessible at all times.

6. An electric appliance of the character described comprising a plurality of circuit-controlling units, one of which is connectible on the service side and another of which is connectible on the load side of an electric meter, the load side connectible unit being provided with means for carrying a fuse, and means for inaccessibly incasing the service side connectible unit while normally permitting access to the fuse of the load side connectible unit, the service and load side units being arranged to serve for meter testing in addition to their normal circuit-controlling functions.

7. An appliance of the character described comprising a plurality of circuit-controlling units, one of which has means for carrying a fuse and is connectible on the load side of an electric meter, the other of said units being connected on the service side of said meter, means for inaccessibly incasing the service side unit while permitting access to the fuse of the load side unit, and means for connecting testing instrumentalities with said service and load side means.

8. An appliance of the character described comprising a service side and a load side connectible circuit-controlling unit, each of said units being provided respectively with means for the removable connection therewith of testing instrumentalities for meter

testing purposes, and means for normally inaccessibly incasing the service side connectible unit while permitting access to the load side connectible unit.

9. In an appliance of the character described, a plurality of circuit-controlling units, one of which serves as a switch and another of which serves as a fuse-holding unit and said units being connectible on the service and load side of an electric meter, said units being arranged to permit of the connection therewith of testing means for meter-testing purposes, and means for normally inaccessibly incasing the service side unit while permitting accessibility to the load side unit.

10. In an appliance of the character described, a switching unit connectible on the service side of an electric meter, a fuse-holding unit connectible on the load side of an electric meter, means for inaccessibly incasing the service side unit while permitting access to the fuse of the load side connectible unit, and means associated with said service and load side units for the removable connection therewith of meter-testing devices.

11. An appliance of the character described comprising a support having a service side and a load side section, said sections being detachable from each other, a meter adapter detachably associable with the service side section of said support, said load side section and said meter adapter being interchangeably associable with said service side section on said support, and means associated with said service side section whereby the interior is made normally inaccessible and whereby said load side section and said meter adapter are secured to the service side section.

12. An appliance of the character described comprising a support having a service side and a load side section, the service side section being in the form of a box and provided with means whereby its interior is normally made inaccessible, a meter adapter associated with said service side section, and means whereby said load side section of said support and said meter adapter are interchangeably associable with said service side section when said means for preventing access to the interior of said main section is inoperative.

13. An appliance of the character described comprising circuit-controlling means connectible on the service side of an electric meter, circuit-controlling means connectible on the load side of said meter, and means for supporting said two means, for inaccessibly inclosing the service side connectible means and for permitting a meter test through the coöperative action of said two first-mentioned means.

In testimony whereof I affix my signature in presence of two witnesses.

JOSEPH SACHS.

Witnesses:
L. L. MARKEL,
HEATH SUTHERLAND.

DISCLAIMER.

1,301,175.—*Joseph Sachs*, Hartford, Conn. ELECTRIC SERVICE AND METER TESTING SYSTEM. Patent dated April 22, 1919. Disclaimer filed August 1, 1928, by the patentee, *Colts Patent Fire Arms Manufacturing Co.*, a Corporation, consenting to and ratifying this disclaimer "in so far as its interest in the aforesaid patent may appear."

Hereby enters this disclaimer as follows:

"He hereby disclaims claims 11 and 12.

"He hereby disclaims all constructions of the character disclosed in the specification or drawings or described in claims 1, 2, 3, 6, 7, 8, 9, 10, and 13 except those wherein the load side connectible means includes an accessible fuse and fuse receiving contacts and all of the remainder of the said means is inaccessibly inclosed.

"He hereby disclaims from the scope of claims 4 and 5 all constructions of the character described therein except those wherein the load side connectible means includes an accessible fuse and fuse receiving contacts and all of the remainder of the said means is inaccessibly enclosed, and wherein the said load side connectible means also includes a circuit opening connecter adapted to be manually opened independently of the service side connectible means and without removing the load side connectible fuse from its receiving contacts."

[*Official Gazette August 21, 1928.*]

PLAINTIFF'S EXHIBIT No. 72

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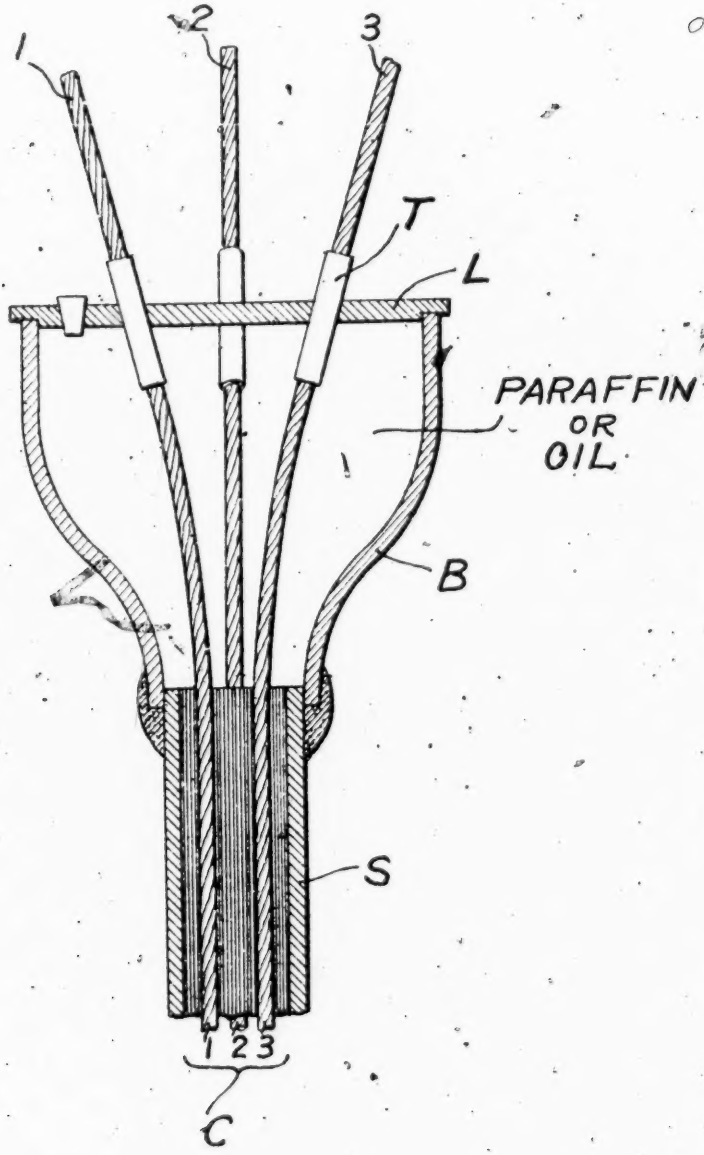

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NO. XVII

HANDBOOK
of
PRICE LISTS, TELEGRAPH CODE AND USEFUL INFORMATION

RELATING TO
BARE and INSULATED WIRES
and CABLES
for the CONDUCTION of
ELECTRIC CURRENTS

BY
JOSEPH W. MARSH

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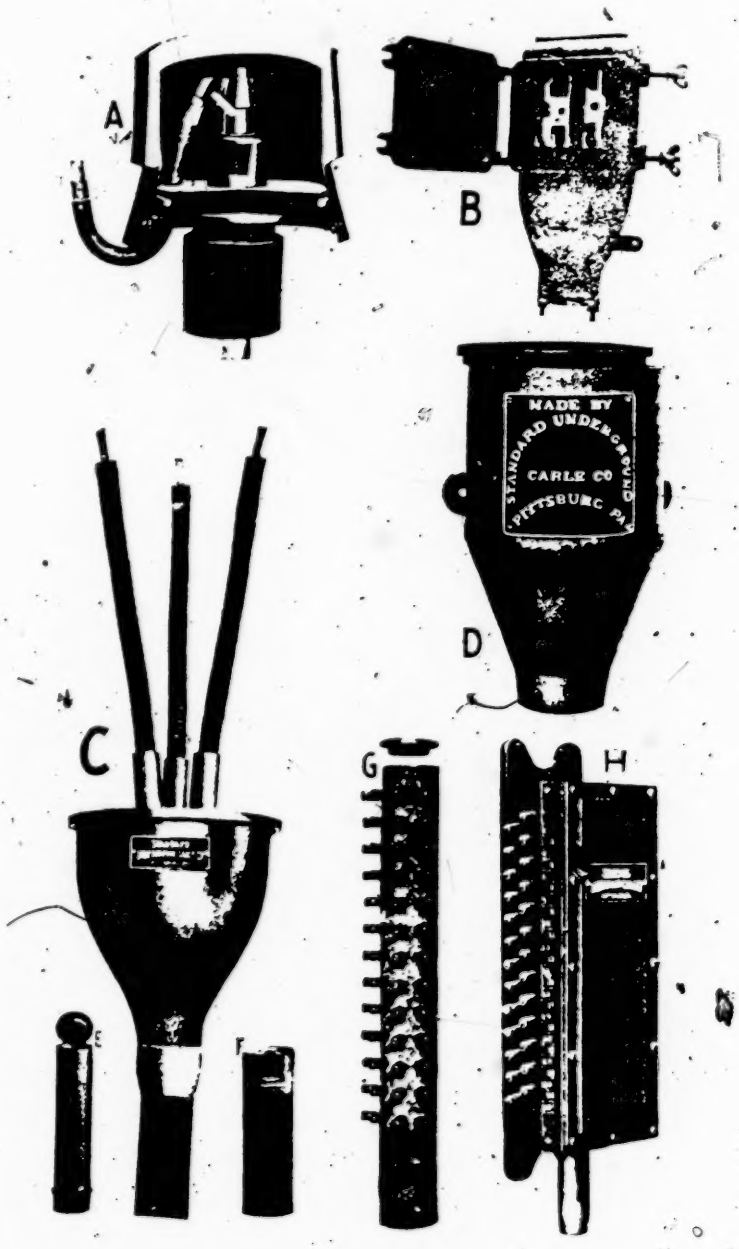
STANDARD UNDERGROUND CABLE COMPANY



A—Acheson terminal. B—Combination terminal and service cut-out box. C—Spun copper terminal with hard rubber cap and mica tubes. D—Cast brass terminal with rubber cap. E & F—Single and duplex hard rubber tubular terminals. G—Hard rubber tubular telephone and telegraph terminals. H—Iron box telephone and telegraph terminals.

BRASS AND COPPER TERMINALS

For Terminating Electric Light and Power Cables

(For description see p. 128. For illustration see p. 42-a)

Diam. of Cable, Inches	Voltage	Kind of Bell	Approx. Diam. Top of Bell	Price	Telegraph Code
up to 1¾	up to 6,000	Cast Brass	4	$ 6.00	genus
1⅞ to 1⅞			5	8.00	geometry
2 to 2⅝			5½	10.00	geranium
1¼ to 2¼	6,000 to 12,000 Volts	Spun Copper	9¼	20.00	ghostly

These prices include hard rubber caps for all bells and, in the case of the spun copper bells, additional mica tubes 10 inches long for reinforcing the insulation at the cap.

ONE-PIECE MALLEABLE IRON CABLE HANGERS

(For description see p. 129. For illustration see p. 151-b)

Stock No.	Width of Opening, Inches	Diam. of Cable to which Applied, Inches	Price per 100	Telegraph Code
1	⅝	½	$3.00	gift
2	⅞	⅝	3.00	giggle
3	⅞	⅝	3.00	gilded
4	1	⅞	3.25	gillie
5	1¼	**1**	**3.50**	**ginger**
6	1⅜	1⅛	3.75	gipsy
7	1⅝	1⅜	4.00	giraffe
8	1⅝	1¼	4.25	girding
9	1½	1⅜	4.50	girlhood
10	1⅝	1⅜	**5.00**	**girth**
11	1⅞	1⅝	5.50	glacier
12	1⅞	1⅝	6.00	gladiator
13	2	1⅞	6.50	glassy
14	2¼	2	7.00	gleeful

NORDYKE CABLE SUPPORT FOR MANHOLES

(For description see p. 130. For illustration see p. 148-a)

For Use as	Price, Each	Telegraph Code
Wall Bracket	$0.20	glen
Extension Bracket	.20	glibly

OZITE OR WARING INSULATING COMPOUND

For Filling Joints, Terminals, Junction Boxes, Transformers, etc.

(For description see p. 131. For illustration see p. 42-b)

Size of Packages	*Ozite Insulating Compound		Standard Terminal Compound	
	Price per Gallon	Telegraph Code (See p. 5a)	Price per Gallon	Telegraph Code
½ Gal. Cans	$1 65	gloaming	$2 15	glover
1 " "	1 50	globule	2 00	glowworm
2 " "	1 40	glomerous	1 90	glucinic
5 " "	1 35	glorify	1 85	glucose
50 " Barrels	1.30	glossary	1 80	gnarled

*No. 1 Ozite is hard, No. 2 is medium soft and No. 3 is soft, at approximately 60° Fah. In ordering state the purpose for which the material is desired and the conditions as to temperature.

cured to the sides of the box by machine screws, and bearing upon a rubber or lead gasket; a suitable number of holes are tapped through the sides of this box and hard rubber bushings are seated therein, while in the bushings themselves are mounted brass binding posts through which the wire connections are made, the posts being numbered. This form of terminal is very substantial, but is also far more expensive than the ordinary hard rubber terminal. It is illustrated on page 42-a.

POT HEADS FOR TELEPHONE AND TELEGRAPH CABLES

Paper or fibre insulated Telephone and Telegraph Cables may be protected at the ends by means of potheads in conjunction with rubber insulated wire, a lead sleeve being wiped on the end of the lead cable, the rubber wires joined to the paper insulated wires, the lead sleeves filled with compound, and the end carefully taped up, as fully described and illustrated in the working directions for Jointing Cables. (see pages 88 and 159.)

TUBULAR TERMINALS FOR ELECTRIC LIGHT AND POWER CABLES

(Price List, page 42)

Fig. 8

Figure 8 illustrates a tubular hard rubber terminal for single wire electric light or feeder cables, either in a junction box or in a water tight pole-box. A is the lead cover of the cable, B the insulation, C the cable conductor, D the binding post having at its lower end an opening to receive the conductor C, and at its upper end a reduced screw threaded portion passing through an opening in a connector E, good contact being secured by thumb nut F, and lock nut G. H is the hard rubber tube, and J is its cap.

The tube may be of lead, in which case it can be secured to the lead sheath A by a solder wipe. (See page 154-b.)

For duplex cables, the tube is flat (see page 42-a) conforming closely to the size and shape of the cable, and preferably closed at the top, (although we may furnish open tubes with double caps, in which case the cap is treated exactly like that of a single wire terminal). This closed tube will be provided with a hole through which to pour the melted compound after the terminal is in position on the cable.

ACHESON ELECTRIC LIGHT AND RAILWAY TERMINAL

(Price List, page 42; Illustration, page 42-a)

This terminal, does not require enclosing in a weather tight box. It can be mounted on the side of a house or pole by means of an iron bracket which we supply if desired, but in case the cables come to the surface through a hollow pole, the terminal is mounted directly on the top of the pole; the legs of the spider or supporter are so arranged as to leave a good ventilating space for the escape of gases from the conduit system. The tap connector and cone are designed to give large bearing or contact surface and so reduce the resistance to the minimum and yet have a readily separable connection to cut out the overhead lines when desired. Instead of a hard rubber terminal, a lead cup is wiped onto the lead cover, because the cup must to some extent support the cable in the pole. A hard rubber cap insulates the conductor from the lead. The metal cover is double, the space between being filled with a powdered non-heat-conducting material, whereby condensation is practically obviated, an important consideration in a device like this.

For working directions as to any of these terminals see pages 139 to 140.

BRASS AND COPPER END BELLS FOR ELECTRIC LIGHT AND POWER CABLES

(Price List, page 43; Illustrations page 42-a)

Electric Light and Power Cables are also protected by various other forms of terminals, lead or brass for low tension single

conductor cables, or in the case of high tension multiple conductor cables by spun copper end bells. In all cases the leading-out wires are connected to the main wires of the cables and the terminals filled with compound, and closed at the top by a hard rubber or other suitable cap.

An interesting form of terminal is that shown on page 42-a, figure B. It is used by one of our customers in the City of Mexico. The photograph shows the construction clearly; and it is only necessary to add that the insulating compound (which occupies the lower portion of the terminal) is covered by an oblong hard rubber disc and is prevented from flowing out at the bottom by a stuffing box of the usual type.

For Working Directions for Brass and Copper Terminals see pages 159 to 160.

AERIAL CABLES AND CABLE HANGERS

Aerial cables are destined for a long time to be an important feature in the construction of telegraph and telephone lines in cities or parts of cities where overhead construction of some kind is still permitted.

Aerial cables represent a long advance over the ordinary overhead construction, for instead of, say, 50 to 100 single iron or copper wires attached to as many insulators on a large number of cross arms at each pole, all the wires are grouped together in a single cable one to two inches in diameter, neatly suspended at intervals of 24 to 36 inches to a slender but strong wire or steel cable which is firmly secured to the poles.

In street railway and electric light service, in many cases, instead of a large number of medium size feeders, say No. 0 to 000 B. & S. G. attached to insulators at each pole, a few feeders of extra large size (we have furnished them as large as 850000 circular mils) can be substituted, thus obviating multiplicity of overhead wires and avoiding, to some extent, public criticism and objection. These large feeders, owing to their great weight, are usually supported in the same way as are telephone and telegraph cables.

The little device by which cables are attached to suspending wires as in the cases above mentioned, is known as **a cable hanger**, and the cable hanger which can be most readily attached to and detached from the cables and the suspending wire *at will*, and which is not easily detached from either *by accident*, must commend itself to the favor of thoughtful, practical men, if at the same time it offers no injury to the cable, can be removed without injury to itself, and is reasonable in price.

A cable hanger which meets all the essential requirements, and which has been extensively used since we first put it on the market in 1890, is the invention of Wm. A. Conner, General Superintendent of our Manufacturing Department, and is known as our

ONE-PIECE MALLEABLE IRON CABLE HANGER

(Price List, page 43; Illustration, page 154-b)

This is a very simple form of hanger, being complete in one piece. It is made of the best malleable iron so as to give the greatest ductility consistent with sufficient strength to support the cables without opening by their weight. They are easily and quickly applied or removed by the special tongs furnished by us. The inner edges of the broad band are beveled so as to avoid all danger of cutting the cable, which is gripped so firmly that it cannot turn or chafe in the hanger, all movement taking place between the round hook and the suspension wire. In ordering give diameter of the cable to which the hanger is to be applied.

These cable hangers are also well adapted for supporting cables around the sides of manholes, in which case staples, driven into the wall at suitable intervals, are substituted in lieu of the messenger wire.

Where an extra good piece of construction is desired and the slight additional expense is no object, we advise placing a piece of sheet lead, say 1-16 inch thick, or a piece of leather or rubber hose, around the cable at the point where the hanger is to be applied; but if this is to be done, the additional thickness must be allowed for in ordering the hangers. In ordering, refer to stock numbers in price list to designate size desired; each hanger bears its stock number. For working directions see page 147.

[fol. 619] DEFENDANT'S EXHIBIT B

May 24th, 1911.

Mr. J. G. Jackson, Secretary, National Conduit and Cable Company, Park Row Building, New York City.

DEAR SIR: Our Purchasing Agent placed order with your Philadelphia office for one barrel of Saturating Compound such as is used by your Company in the make up of 13,000 volt cables. I am enclosing herewith copy of letter received by our Purchasing Agent from your Philadelphia office.

I will explain as follows, why and how we propose to use such a compound: in some of our stations where the temperature is high and the cable end bells, or pot heads, are placed considerably higher than the run of the cable, we find that due to the heat and gravity the saturating compound has left the high end of the cable, the cables become dry, and we have found several of our recent breakdowns on cables in such dry sections. We have thought to remove the heavy compound that now fills our end bells, in cases above mentioned, and fill such end bells with the same saturating compound as is used in the make up of these cables, believing that the heat and gravity will in time cause this compound to go down into the dry section of cables and it is our purpose to keep these end bells filled until the cables in question have taken all of the saturating compound that they would take.

If our purpose is feasible, I would thank you to accept and [fol. 620] fill our order as early as possible, and if it is not feasible, I would be very glad to have you or your Engineer advise us why our purpose is not feasible.

Yours truly, E. D. Edmonton.

C. C. to Mr. A. Banks.
EDE:C.

DEFENDANT'S EXHIBIT C

Copy

Received May 23, 1911.
Office Storekeeper.

The National Conduit & Cable Co., Philadelphia, Pa.

5/22/1911.

Mr. A. Banks, Purchasing Agent, Con. Gas Elec. Light & Power Co., Baltimore, Md.

Req. #867

DEAR SIR: Referring to your recent order for I BBL. of insulating compound such as is used in 13,000 volt cables, we wish to say that this compound is not for sale, and as a [fol. 621] matter of fact would be quite useless to you without proper handling when it was received.

Yours truly, Signed: National Conduit & Cable Co.

NOTE: Mr. Heyden:

Kindly advise us relative to the above.

A. Banks, Pur. Agt., per W. T. C.

DEFENDANT'S EXHIBIT D

(Letterhead of The National Conduit & Cable Co.)

May 26, 1911.

Mr. E. D. Edmonton, Consolidated Gas Electric Light & Power Co., Baltimore, Md.

DEAR SIR: Replying to your favor of the 24th instant, we have instructed our factory to ship you one barrel of insulating compound, for which we will charge you 60¢ per gallon f. o. b. our factory Hastings-on-Hudson, N. Y.

Yours very truly, The National Conduit & Cable Co.,
Martin A. Howard.

MAH/K.

[fol. 622] DEFENDANT'S EXHIBIT E

DISTRICT COURT OF THE UNITED STATES, EASTERN DISTRICT OF NEW YORK

In Equity. No. 5474

ELECTRIC CABLE JOINT COMPANY, Plaintiff,

against

BROOKLYN EDISON COMPANY, INC., Defendant

Stipulation

It is stipulated and agreed by and between the parties hereto, represented by their respective counsel, that if Harry Morecraft, custodian of the old files of the Consolidated Gas Electric Light and Power Company of Baltimore, Maryland, was called and duly sworn, he would testify as follows:

1. My full name is Harry Morecraft. I am 64 years of age, I reside at 1632 Belt Avenue, Baltimore, Maryland, and am employed as custodian of old files of the Consolidated Gas Electric Light and Power Company of Baltimore, Maryland. I have been with this company for upwards of 24 years and have been in charge of old files for the past 16 years.

2. Within the past month I was given the number of certain vouchers covering payments to National Conduit [fol. 623] & Cable Company during the year 1911, among them being Voucher No. C-4640. I found this voucher, together with an invoice attached, in its proper place among vouchers of that year. The invoice is dated June 1, 1911, and is an invoice of the National Conduit & Cable Company for one barrel of cable compound. It is stated thereon to be "As per order No. Let. 5/24/11," which means that the compound was shipped and billed according to my company's letter of May 24, 1911.

3. Photoprint copies of the voucher and invoice are marked "Morecraft Exhibit A" and "Morecraft Exhibit B," respectively.

It is further stipulated and agreed that this stipulation, together with the exhibits marked "Morecraft Exhibit A" and "Morecraft Exhibit B" and attached hereto, may be introduced in evidence; reserving to the plaintiff all right of objection to the materiality and relevancy thereof.

Electric Cable Joint Company, by D. Anthony Usina, of Counsel. Brooklyn Edison Company, Inc., Monroe & Byrne, by John D. Monroe, of Counsel.

New York, N. Y., April 14, 1932.

(Here follow parts of Exhibit E, side folios 624-627)

EE 10770

S/A 17906

E. B.

New York, June 1st, 1911.

8916

Consolidated Gas, Electric Light & Power Co. of Baltimore,

Baltimore, Md.

IF THIS BILL IN ANY RESPECTS DIFFERS FROM YOUR UNDERSTANDING OF PURCHASE, PLEASE NOTIFY US AT ONCE AS SETTLEMENT IS EXPECTED TO BE MADE STRICTLY IN ACCORDANCE WITH PRICE AND TERMS ON BILL.

BILL OF LADING WILL FOLLOW

DR. TO THE NATIONAL CONDUIT & CABLE

EXECUTIVE OFFICE 41 Park Row New York

TERMS CASH 30 days

SHIPPED VIA Knickerbocker & B. & O. P. F. - collect

5618 Bay 867

PAYABLE IN NEW YORK FUNDS. INTEREST ADDED AFTER DUE DATE.

	CHECKED BY	EXAMINED BY
1 Barrel of Cable Compound		
57 gallons @ 60¢ gal.	$	31 80
		37
		31.48

EXAMINED JUN 7 1911

167 HUDSON ST. STOCK

NOTICE ...% for cash 10 days.

P. O. P. Hastings

SHIPPED FOR YOUR ACCOUNT.

AS PER ORDER No. Let. 5/24/11

TO you at Lexington & Liberty Sts.,

Baltimore, Md.

Electric Stores Department.

DEFENDANT'S EXHIBIT E

506A

624

JUN 2 - 1911

JUN 10 1911

18½ MONUMENT ST. STOCK.

Reverse of bill dated June 1 1911

ACCOUNTS PAYABLE

VOUCHER
No. C 4640

CONSOLIDATED GAS ELECTRIC LIGHT & POWER CO. OF BALTIMORE

6/7/11	Less 1%	631 48

DATE PASSED JUN 12 1911

PAYABLE TO THE NATIONAL CONDUIT & CABLE CO. - - -

5061

627

ACCOUNTS PAYABLE VOUCHER No. C 4640 INDEXED

TO The National Conduit & Cable Co.

$31.48

MONTH OF June, 191

GAS DIVISION MBW

ELECTRIC DIVISION

137 Monument St. 631.48

[fol. 628] DEFENDANT'S EXHIBIT F

(Letterhead of The United Electric Light & Power Company)

File Report on Joints and H. T. Cables

July 7, 1914.

Mr. Philip Torchio, Chief Electrical Engineer, The New York Edison Company Building.

DEAR MR. TORCHIO: Receipt is acknowledged of your two favors under date of the 3d inst., one attaching information collected by you while abroad in connection with high tension cables, manner of constructing joints, etc., the other submitting comparative data with regard to operating costs as between the 201st street station and the Rummelsburg station of the Berliner Elektricitats-Werke.

With regard to the contemplated visit on the part of your Mr. Rabe to Boston for the purpose of inspecting their process of making joints, I should like very much to have a representative of the United Company accompany Mr. Rabe on this trip, and I have asked Mr. McCoy to confer with you on the subject.

Yours very truly, Frank W. Smith, Vice-President.

[fol. 629] DEFENDANT'S EXHIBIT G

File 213-F

High Tension Cables and Joints

Direktor Wilkens of the Berliner Elektricitats-Werke arranged with the A. E. G. Company to make up a high tension joint at their factory for my inspection. The attached photostatic sketch is a reproduction of a rough sketch which I made while inspecting the work. It is given to illustrate the method but not the actual detail dimensions.

Mr. Wilkens had also last May sent me a description of the vacuum process, an abstract of which is herewith attached.

The Berliner Elektricitats Werke has in service about 230 kilometers (137 miles) of conductor 2/0 B & S 30,000 volt cable, having an insulation of 7.3 millimeters (9/32″) around each conductor and 7.3 millimeters (9/32″) jacket, a total of 14.6 millimeters (18/32″).

The cables are tested after installation for 30 minutes at 30,000 volts, 50 cycles. The length of a cable tested, I understood, was as large as 20 miles.

In a year and a half of service with 200 kilometers (119 miles), they had the following faults:

15 in joints, about 3 in cables.

Of the 15 faults in joints, the greater number were in old joints made without the vacuum process. With the [fol. 630] vacuum process joints they had only a few faults, attributed to defective workmanship.

General

All of these cables are steel armored and laid in earth.

Vacuum Splices

The practice of filling high tension cable splices under vacuum is adopted on single and multi-conductor cables for 22,000 volts and over.

The procedure insures the complete elimination of moisture and fills all the spaces with compound.

The lead sleeve is made in three parts; one cylindrical middle piece and two funnel shaped end pieces.

These parts are secured to each other and to the lead sheeting by means of wiped joints.

The copper connectors of the conductors are normally not wrapped, but the joints are kept apart from each other and the lead sleeve by means of impregnated paper tubes, slipped over the connectors.

The compound at normal temperature is semi-liquid and is similar to the compound used for saturation of cables.

1 h. p. bensin motor driven air pump with rotating piston is used for pumping out the splices.

The obtainable vacuum is about 1/10 m. m.

During the pumping which lasts about ¼ of an hour, the splice is well heated by means of a blow-lamp.

[fol. 631] The compound is previously heated to about 110-120° C, and is poured into the splice by means of a funnel; the vacuum, which during the filling process diminished is again restored in the space above the level of the compound.

As soon as the compound is settled, which can be observed through small peep holes in the filling apparatus, the atmospheric pressure is restored, the piping used for filling removed and replaced by small funnels.

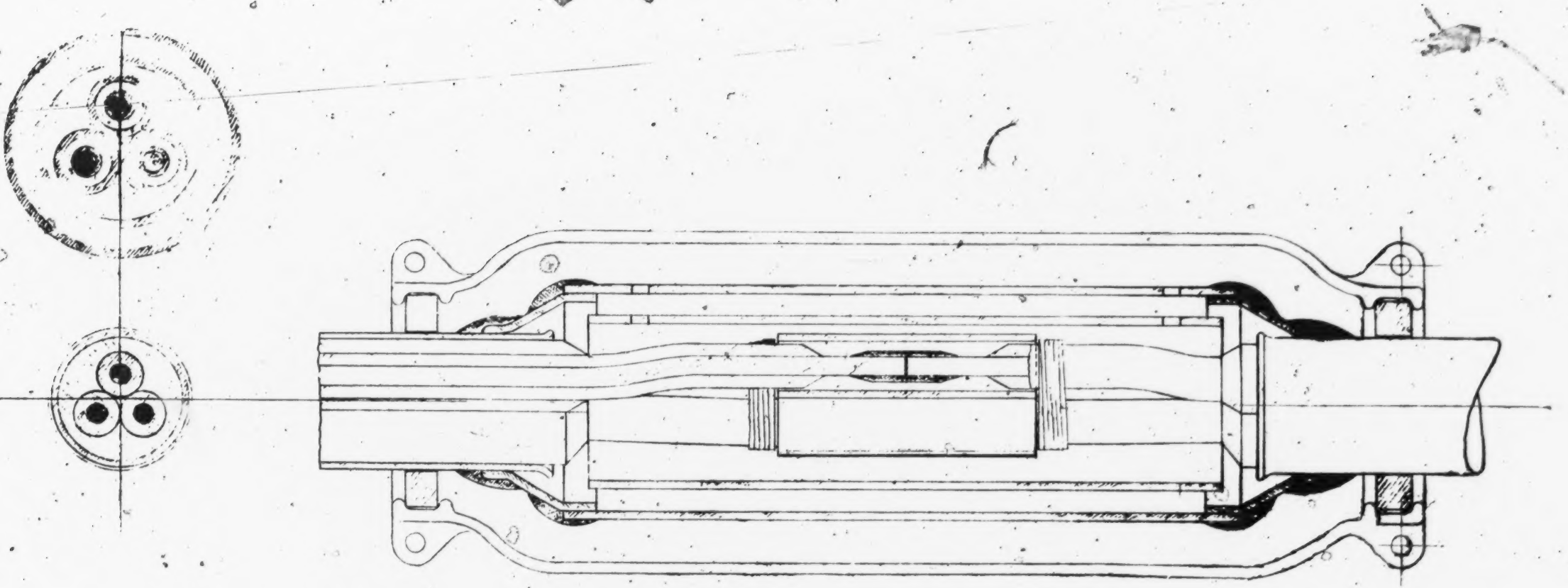
The compound is kept warm in these funnels for the purpose of replacing the shrinkage, until the splice is completely cool.

As a protection against mechanical injuries, the splice is placed into a cast iron box, which is also filled with compound.

510A

1632

PART OF EX G



[fol. 633] DEFENDANT'S EXHIBIT H

(Letterhead of The Edison Electric Illuminating Company of Boston)

July 17, 1914.

Mr. Philip Torchio, New York Edison Company, 15th Street and Irving Place, New York City.

DEAR MR. TORCHIO: We have resumed laying the 25,000 volt armored transmission cable both of domestic and English manufacture, and probably will be laying it for at least four days during the coming week. Jointing is also in progress on this cable so that your representative may have an opportunity to witness all branches of the work.

I would, therefore, suggest that you send your representative here during the early part of the coming week. We would prefer to have you wire us when we may expect him. We will be pleased to give him all the information and facilities for witnessing the work possible.

With best wishes, I am

Yours very truly, W. H. Cole, Supt. Street Engineering Dept.

WHC/RJW.

Mr. Rabe: Note this and my reply.

Torchio.

Noted: A. R.

[fol. 634] DEFENDANT'S EXHIBIT I

(Letterhead of The Edison Electric Illuminating Company of Boston)

July 22, 1914.
File.

Mr. Philip Torchio, Chief Electrical Engr., New York Edison Co., 15th Street and Irving Place, New York City.

DEAR MR. TORCHIO: I beg to acknowledge receipt of your communication of the 20th inst., and wish to advise you

that any time during next week would be very convenient to this Department for a visit from your representative.

Yours very truly, W. H. Cole, Supt. Street Engineering Dept.

WHC/RJW.

DEFENDANT'S EXHIBIT J

File 213-A

High Tension Cables and Joints

High Tension Cables and Joints, General

On July 27, 1914, I visited Mr. W. H. Cole, Superintendent Street Engineering Department of Boston Edison [fol. 635] Company, at No. 39 Boylston Street, Boston, Mass. Mr. Cole arranged for an inspection and examination of their new underground transmission line under construction and forming part of a ring system from Dedham, Mass., looping via sub-station at Norwood to Walpole, suburbs of the Hub City, and almost in line to the southwest.

Dedham is about 12 miles from Boston via route of underground feed at 13,000 volts, which is the beginning of the new work. Approximately 5½ miles of subway was already installed in anticipation of cable work to Norwood. From here, armored cable was being laid in open trench on country roads to Walpole about 5½ miles further on. Operating voltage to start with 15,000, with a view to 25,000 ultimately.

Two cables of practically similar type—one of General Electric Company's make and the other made by the British Insulated and Helsey Cables Limited, Prescot, Lancastershire, England, were laid side by side in ducts and trench over a total distance of about 11 miles between limits described.

Cable

Plain:

Cable for subways between Dedham and Norwood was plain lead—3 conductor—132,716 c. m. per phase—Split concentric, 0.1" paper between splits—8/32 over concentric

conductor and 8/32 jacket, 0.17 lead. This made up a cable 3" in diameter over all. (See Sketch "A".)

[fol. 636] Armored:

Lead and core as above. Over this a layer of burlap compound and burlap, then stranded armor (.125 wire) and a second treatment of burlap compound, and burlap over all.

G. E. and English cables are practically identical, except that armor on G. E. was slightly heavier gauge wire, while burlap compound and burlap was more substantial on the English cable, making possible a better electrolysis resisting cover. Outside diameters respectively were 4⅛ and 3⅞ inches.

Organization

The G. E. gang consisted of a splicer and helper and a foreman who had the close supervision of cable laying; a G. E. gasoline winch being used for both cables. The jointer and helper made one joint per day on both types of cable and attended to the outer box and pitch filling on armored cable work.

The English gang consisted of two splicers, each with a mate and helper. One splicer averaged about three splices per week including vacuum filling. These men were under supervision of a graduate English engineer who payed considerable attention to details of splicing and also watched his individual sections of cable at periods of installation.

Cable drawing into ducts on early half of work was done by Contractor Sugden and trench work on armored part by Snow, another local contractor; both of these concerns, I [fol. 637] understand, handle most of these respective types of local work in Boston. An inspector of Construction, representing Mr. Cole, was continuously on the job.

Laying

Plain Cable:

Dedham to Norwood, 5½ miles, drawn into 3½" fibre conduit laid in concrete. 3' x 4' manholes spaced about 400 feet apart.

Armored Cable:

Norwood to Walpole, 5½ miles, into an open trench, 2 feet wide, 3 feet deep. Cable was drawn by a gasoline winch over rollers, spaced on bottom, at intervals of 25 feet. Time of drawing (section 500 feet) 10 minutes. After cable is laid all rollers are removed except two (2) and a second strain taken to straighten cable. However, a little slack allowance is recommended with a 3 foot lap for jointing.

G. E. and English cables were placed on opposite sides of trench and covered by a protective 2" x 8" plank of "Kyanized" spruce. Back filling is carefully performed around cables by screening earth filled adjacent to them.

Jointing

The detail drawings are available and I will refer here, only to the broad practical features of interest.

[fol. 638] General Electric:

Plain—Straight concentric jointing was done practically similar to our own type of low tension joint with allowance in detailed splice measurements to suit higher voltage concerned. Compound was filled at Atmospheric pressure.

Armored—Straight concentric joints are again as above but over the wiped lead sleeve is placed a long split cast iron box, similar to our own Edison tube box, though without clamps. This box is bolted and fits snugly over wire armor at both ends of joint opening, a bond strap having previously been soldered closing this gap. This cast iron box is filled with compound at atmospheric pressure and over all a wooden box, enclosing everything, outer jute to jute, is placed and this filled with common pitch.

Split Concentric Joints—In making this joint the cable is scored as shown fully in left half of sketch "B", with a gap at centre of inner core of 5/8". The scoring in detail is exactly similar on right hand except that conductor is longer to allow for slipping back of paper tubes used in insulation. Short links as shown in sketch "C" are used to transpose the outer to inner and inner to outer core of one conductor. These are placed as shown in sketch "C.C." and soldered, and a bobbin made of 6-8 plys of 8 mil. paper

is folded to form a figure L with short ends forming a double thickness at centre of gap. After this, impregnated cotton tape is tightly wrapped entirely covering the links, care being taken to fill well all crevices formed.

[fol. 639] Paper tubes of suitable diameter 5/16" thick by 6" long are then drawn over conductors and a larger one over all. A lead sleeve, 24" x 5½" bore x ⅜" gauge lead wiped and filled with G. E. compound at atmospheric pressure completes the joint proper. An outer protection, described in previous paragraph, completes the job.

English:

Following its foreign practice the British Cable Company has made the transposition joint its standard on all concentric split conductor cables of high voltage. Conductors are therefore transposed in each joint on plain and armored types and differ only in their outer construction, whether in subways or open trench.

In making transposition joint, the cable is cut and scored, as per sketch "D", referring to one conductor only.

Two short pieces of woven copper braid (9" x ½" x ⅛") are bound to top and bottom sides of left hand inner cores of all three conductors. A like job is made on opposite (right hand) side, except that braids are fastened to vertical sides of inner core of each conductor. The bound ends are tinned and solder poured, leaving six free ends of copper braid on each side of joint.

Sketch "E" shows copper braid in position on inner core of one conductor temporarily laid down on outer core of right hand conductor, (vertical plane). This sketch reversed and in plan shows braid positions on conductors from right hand side of splice.

The free ends—two from each side—are threaded through [fol. 640] a fibre separator tube having a solid core at centre and these ends laid down now permanently on outer core tinned and soldered. See photo "F". Over this, three paper tubes are placed, one over each conductor, and three porcelain separators positioned at right angles and dividing joint into four equal parts. The entire joint up to this point is treated to a good "boiling out" process, "basting" as the Englishmen term it.

A split brass casting 7" bore with a wide, flat and ground flange, top and bottom, encloses this joint lead to lead.

Upper (having two filler holes) and lower halves are drawn tightly together by threaded holes in lower casting and flathead brass screws through upper shell. The lipped ends extending over lead of cable are poured and wiped to cable sheath and the split sides of casting tightly soldered with blow torch and bar solder. Before allowing time to cool off, so that any possible moisture is still in form of vapor, one filler plug is removed, air line attached, and a short vacuum put on. (3 minutes.)

Vacuum Process

Briefly, this gear consists of a small hand pump, gauge, large funnel reservoir, brass receiver having glass window at each end and a number of valves to control the various operations.

When set up for taking a vacuum and consequent filling, it is connected as shown in sketch "G".

Pump is started with all valves open except "A" and [fol. 641] kept running while gauge registers about 25" for a few minutes to withdraw all possible moisture vapor. Valve "D" is then closed and pump stopped. If gauge does not register a fall of more than 1" per minute for three minutes the job is considered tight and compound admitted to funnel. Pump is again started and valve "D" opened and with gauge registering 25" or better valve "A" is slowly opened allowing compound to run into joint. In a short space of time joint fills and when compound begins to overflow from here into receiver, which is closely observed, word is given to stop pump and all valves closed and gear disconnected and removed.

Two lengths of 1½" pipe about 2 feet long are subsequently threaded into filler plugs, one acting as a filler and the other as a breather. Compound retained in first mentioned pipe is allowed to act as a reservoir for two hours for gradual settling of compound in splice proper, upon

---

* Compound used by British Company at ordinary temperature is about the viscosity of molasses. During the process of joint making it is heated by a helper over a coke fire to a temperature of 300° F., and allowed to cool to 170° before filling into a joint, thermometers being used to hold to this rule as close as practical.

which plugs are reinserted and left until following day when a final filling is made at atmospheric pressure. This quantity varies between a pint and a quart of compound.

Armored Cable:

On this type of cable jointing, instead of the brass split [fol. 642] casting described for use on plain cable in subways, a cast iron ½" thick barrel with 7" bore forms the shell of armored type joint. A separate iron casting threaded to the barrel draws up tightly a brass casting forming a ferrule over cable. This is solder poured and wiped to lead sheath and forms a tight joint which is subjected to a 25-27" gauge test, as on plain manhole joint. The entire joint is then vacuum fill as already described.

A bond strap joining lead armor for continuity across joint gap is put on and then the whole outer jute to jute is enclosed in a fairly substantial box which is filled with common pitch as described on G. E. cable paralleling it.

Conclusion

I was much impressed with the general care taken with all construction details of the job. Armored cable was drawn and placed in trench and great pains taken to cause a soft cushion fill and sufficient slack allowed for possible sags. Protective plank had ample projection insuring greater safety from damage due to foreign interference. This is an important feature, as damage might occur from operations at right angles to line of cable, such as plumbers, water and sewer cuts, or gas connections, etc. The danger from this kind of work, particularly in a developing suburban section, is ever present and would require almost daily inspection, possibly by motorcycle.

Repairs in midwinter on armored cable will require very definite location test work so that these can be made to in- [fol. 643] sure a minimum out of service period. Maintainance organization also should be equipped so that reels of cable, where same are required for repairs in duct line, could be properly heated in open country, before drawing in.

Splices on G. E. cable appear readily able to stand the specified breakdown tests, and I understand have been tried at factory for much higher.

The margin of safety on English type of splicing work is extremely high. They look good enough for 50,000 volts operating.

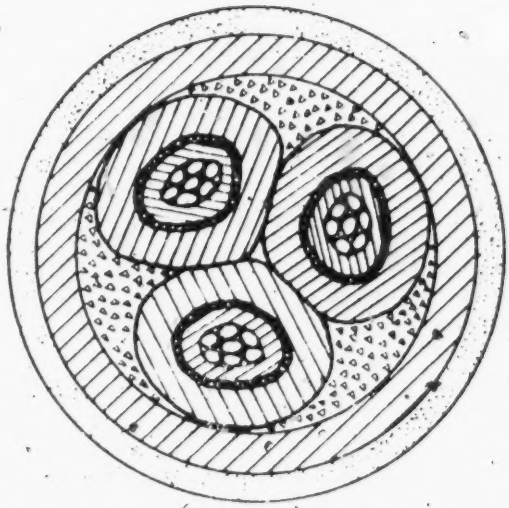
Detailed costs figures were not available but approximately G. E. and foreign splices cost about $15.00 and $80.00 respectively. Here two cables lay side by side in both types of underground construction and whether commercially this difference is warranted will be demonstrated by Boston Company's experience. Personally, I would like to see early comparisons on the 35,000 volt basis.

The vacuum process up to 15,000 volts seems hardly necessary, except as in the Boston case, when higher ultimate operating voltage is contemplated or might become desirable.

AR./PB.

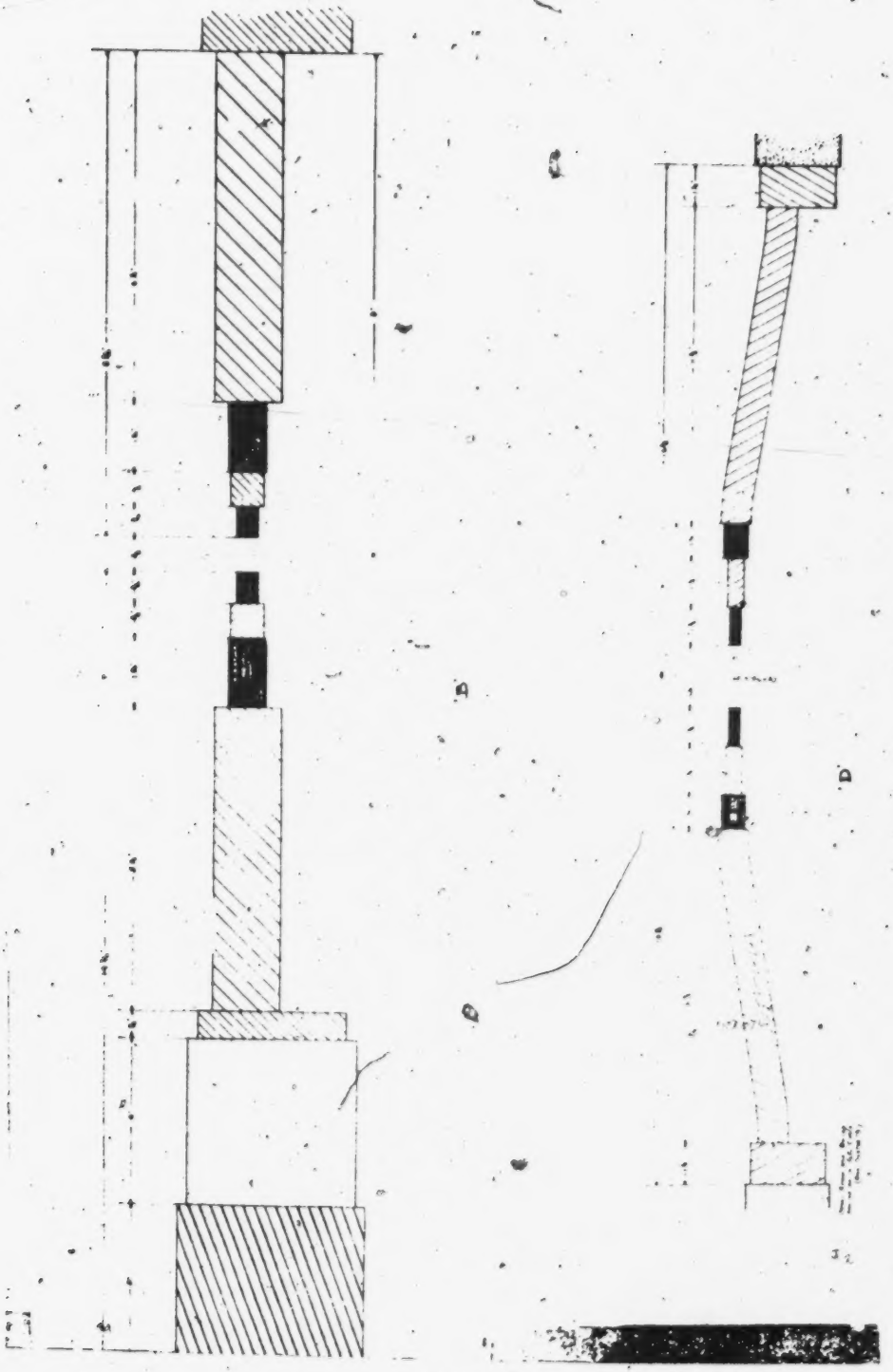
(Here follow drawings, side folios 644-648.)

518A
644

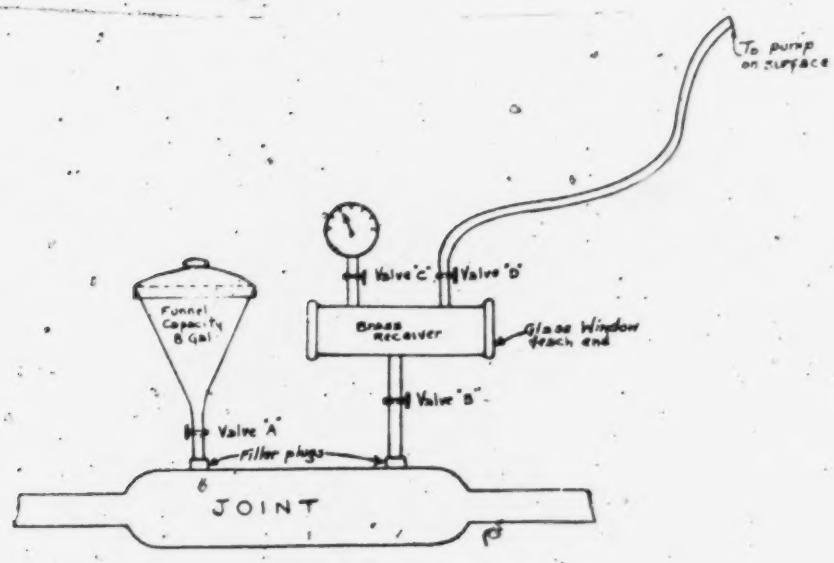


(Full size)

"A"



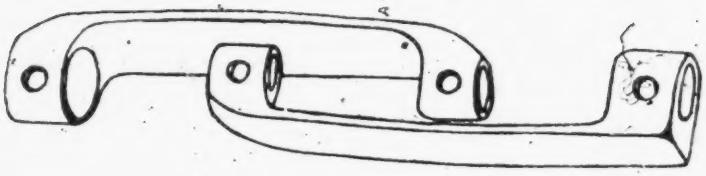
"E"


To pump on surface
Valve "C"
Valve "D"
Funnel Capacity 8 Gal
Brass Receiver
Glass Window each end
Valve "B"
Valve "A"
Filler plugs
JOINT

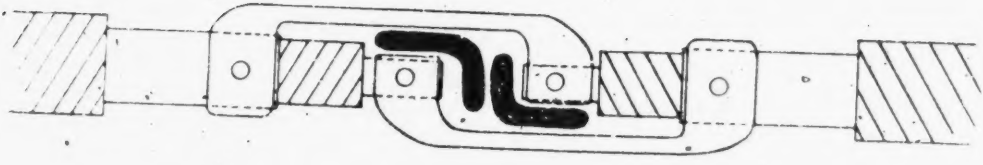
"G"

5180

647



"C"



"CC"

[fol. 649] DEFENDANT'S EXHIBIT K

The Safety Insulated Wire and Cable Co., Bayonne, New Jersey

President, 114 Liberty Street.

New York July 23rd, 1914.

Philip Torchio, Chief Electrical Engineer,
New York Edison Company,
130 E. 15th St., N. Y.

MY DEAR MR. TORCHIO: In accordance with our recent conversation on the subject of jointing compound, I am sending you herewith a sample of the compound I spoke to you about, which is made from pure resin, and has no additions of any kind.

I am sending this more with a view of getting your idea as to its hardness than anything else.

It has the viscosity of water at a temperature of 162° C. and flows readily at 100° C., and contains about 70% saponifiable. This can be made harder if you so desire, and by the addition of asphalt could even be brought down to the low hardening point of paraffine, although in our opinion it is much better to leave it in its pure state, as at ordinary working temperatures it would not run out of a joint.

This has also the advantage over paraffine of its high breakdown qualities and lack of porosity, which is one of the great troubles with paraffine.

I should be glad to have you advise me what you think of the consistency, and also give me the further data in [fol. 650] regard to the paraffine which you now use, so that I can give you the comparative figures on softening.

Yours very truly, Le Roy Clark, President.

LCR/JR.

DEFENDANT'S EXHIBIT L

The Edison Electric Illuminating Company of Boston

General Offices, 39 Boylston Street, Boston, Mass.

September 12, 1914.

Philip Torchio, Chief Elec. Eng., The New York Edison Co., Irving Place & 15th St., New York City.

DEAR MR. TORCHIO, I beg to acknowledge receipt of your communication of the 2nd inst. received during my absence from town.

In accordance with your request, I take pleasure in mailing you under separate cover three samples of compound used in connection with our 25,000 volt cable installation. The sample marked "B. I. H. compound for sealing joints" is used in filling the large sleeve by the vacuum process and is substantially the same compound as is used in impreg- [fol. 651] nating the cable paper. The sample marked "B. I. H. sealing compound for end bells" is the British Insulated and Helsby Cable Co. standard compound for end bell work. The above mentioned samples, of course, were used in connection with the British cable furnished by the British Insulated and Helsby Cables, Ltd. Sample marked "General Electric compound for sealing joints" is standard #227 G. E. compound and, so far as our experience with 15,000 volt work is concerned, has proved to be very satisfactory. This third sample was used only in connection with the cable furnished by the General Electric Co.

Any additional data you may require with reference to these cable installations, I shall be pleased to furnish upon request.

Very truly yours, W. H. Cole, Supt. Street Engineering Dept.

WHC-CWL.

(Notations:) File—Joints. Mr. Noe: Have Mr. Rabe see me when samples arrive. T. Done. J. B. N.

[fol. 652] DEFENDANT'S EXHIBIT M

Joints

This Copy for Mr. Noe

September 26, 1914.

Mr. Le Roy Clark, 114 Liberty Street, New York City.

DEAR MR. CLARK: Regarding the subject of compound for filling joints which I had up with you after my return from Europe and in relation to which I understand you have already furnished samples to our Mr. Rabe, which he has used in a first test of making joints by vacuum, I wish to bring up the matter of immediate urgency of coming to a final decision as to the exact composition to be used for the compounds which we shall require in the immediate future for the installation of the 22,000 volt cables which we ordered a few days ago.

I wish to get from you the per cent. of rosin and rosin oil that you have used in the last sample submitted.

For your information, I would state that from an analysis made of a sample of compound used by the British Insulated and Helsby Company in connection with their installation in Boston, we found the compound to consist of 43% of rosin (solid) and 57% of wax tailings. I recollect that you spoke to me about wax tailing several years ago and I imagine that you are familiar with this product, which I understand is obtained from the destructive distillation of paraffine petroleum residuum. Of course we do not wish [fol. 653] to have any wax tailing used in the compound for your cables, as we think the compound should be made of the same material as the compound used for impregnating the cable itself. The foreign manufacturers, however, as they use mineral oils, naturally adopt the wax tailing in place of the rosin oil that we contemplate using.

In a few days I shall advise you of the probable amount of compound that we require for the 22,000 volt cable installation. I imagine that it can be obtained on short notice. If I am mistaken in this assumption, please advise.

Any assistance that you will give us in this matter will be appreciated.

Yours very truly, (Signed) Philip Torchio, Chief Electrical Engineer.

PT/D.

Copies sent to Messrs. Rabe and Noe.

DEFENDANT'S EXHIBIT N.

The Safety Insulated Wire and Cable Co., Bayonne, New Jersey

October 8th, 1914.

Philip Torchio, Chief Electrical Engineer, The New York Edison Company, Irving Place & 15th Street, New York City.

DEAR SIR: I am sending you herewith two (2) cans of Regular Insulating Oil taken from our saturating tank at [fol. 654] ten o'clock this morning; these samples were obtained by placing the two (2) cans on top of a reel of cable and then subjecting the whole to the regular treatment received by cables, viz., drawing the vacuum which was 27", maintaining this vacuum for one half (½) hour, then opening the line to the storage tank of oil and drawing in by this vacuum sufficient oil to completely submerge cable and cans,—the vacuum was then broken, cover of tank raised and samples taken from the tank. The proceedure which we carried would give, to my mind, a sample of oil which is the exact composition in every way of that which is forced into the paper cable.

While attempting to make a new joint this morning I found that the solder at the point where the tubes go into the lead sleeves were not tight, therefore it will be two o'clock this afternoon before I can have things in readiness for a new trial, and think it best to delay my visit until after this joint is made inasmuch as it practically completes the preliminary experimental work which I had mapped out for this vacuum method.

Would you prefer me to meet with Mr. Rabe and together prepare a report for you in order that you may be saved a certain amount of time, or would you prefer that I meet with Mr. Rabe at your office?

Yours very truly, Dorris Whipple, Chief Chemist.

DW/K.

[fol. 655] DEFENDANT'S EXHIBIT O

The New York Edison Company, Irving Place and Fifteenth Street

Office Memorandum

In re 22,000 Volt Cable Joints

October 21, 1914.

Messrs. Frank W. Smith, W. E. McCoy, Henry Stephenson, A. Rabe, J. B. Noe:

The attempt to use some filling compound which should have relatively the same composition as the saturating compound used in the cable as per European practice, has failed to give satisfying results.

One of the main objects of securing a compound with a higher melting point than paraffine was not accomplished. If we could rely on operating the cable normally at temperature below 160 F., the soft compounds, as in European practice, would be very excellent. Under the American conditions, however, of cable installation in ducts and heavier watt loss per foot of cable, the temperature must necessarily be higher.

Especially in connection with the New Haven service of high load factor and fluctuating loads, the heating will be considerably greater than on our average cables. It seems, therefore, essential that for this installation the compound should have a very high melting point, so that it will not run.

[fol. 656] After full discussion of the subject with Dr. Whipple and Mr. Rabe and in the light of other chemical tests reported by Mr. Menges, we have come to the conclusion that a mixture of the General Electric Nos. 227 and 229 compounds would probably give the best results, as its melting point is about 180° F. In combination with this compound I think mica tubes would be preferable, as I am not certain that this compound would easily penetrate the paper wrapping of a wrapped joint and fill all of the possible interstices left under the wrapping.

Mr. Rabe is experimenting on sample mica tubes.

A completed joint so made will be ready for inspection in the next few days.

On the suggestion of Mr. Alverson of Buffalo, we are also experimenting with a compound called B-7, manufactured by Messrs. Trotter & Company of Brooklyn. He stated that this concern furnished the material to the General Electric Company. The price of this compound is about one-sixth or one-eighth of the General Electric compound. Samples have been secured and experiments will be made.

At the same time experiments on combination of saturating oil and paraffine and other mixtures are being carried on by Dr. Whipple at the Safety Works.

My recommendation at present would be to install the 3-22,000 volt New Haven feeders as follows:

One (1) feeder with mica tubes over each conductor, and mica tubes over all three with General Electric mixture of Nos. 227 and 229 compounds, using the vacuum process. [fol. 657] Two (2) feeders to have the joint wrapped with paper tape, as per standard practice, and with paraffine filler poured with the vacuum process.

———, Chief Electrical Engineer.

PT D.

(Notations:) Fit Joints—Studs. See Revised.

DEFENDANT'S EXHIBIT P

In re 22,000 Volt Cable Joints

November 11, 1914.

=183

Messrs. J. W. Lieb, Frank W. Smith, A. Maxwell, W. E. McCoy, J. B. Noe, A. Rabe:

Referring to last week's and this week's splice burnouts on feeders 201 and 202, these burnouts were all on remade joints. From the investigation made there seems to be no doubt that the cause of the burnouts is due to the fact that the manufacturer's insulation on the individual conductors of the sector cable has wrinkles which extend from the metal union outward and cause air interstices to exist between the mill insulation and the hand wrapping. These

[fol. 658] interstices are not filled by the filling compound, which fails to penetrate into the inner layers.

The fact also that the insulation is cut sharp at right angles to the copper conductors without tapering off has made this weakness more pronounced than it would have been if the proper tapering of the insulation had been applied. This matter will be the subject of another memorandum.

The characteristics of the burnouts give sufficient evidence to confirm the above explanation of the causes of the burnouts.

The remedy will consist either (1st) in tapering the manufacturer's insulation and applying the hand wrapping with a liquid binder around the conductors and between layers, so that the joint will be uniformly saturated before the paraffine filler is poured in, or (2nd) by using mica tubes around each single conductor and a mica tube over all three conductors, then filling the joint by the use of the vacuum machine.

This method will especially be used on the 22,000 volt cables for the New Haven service. For that service, tubes will be 7" long. The manufacturer's insulation around each conductor will be slightly tapered to allow an easy flow of the filling compound into the space around the conductor. The joint will be filled by the use of the vacuum machine with a rosin and asphalt compound having a melting point of about 200° F. and to be poured at 300° F.

One of these joints so made by Mr. Rabe, except that the tubes are 5" long instead of 7", has been sent today to Mr. Maxwell prepared for a sustained high voltage test, the intention being that about 50,000 volts be applied and kept [fol. 659] on the joint indefinitely, unless breakdown occurs. Mr. Maxwell will please notify me of the time when the test is started and at short intervals as to results. If the joint will stand for a long period, the voltage will be raised to 70,000 or 75,000 volts until breakdown occurs, when the joint will be cut apart for a physical inspection of the filling.

All of this work is of pressing importance and the parties interested should give it their prompt attention.

——, Chief Electrical Engineer.

PT P.

DEFENDANT'S EXHIBIT Q

February 2, 1915.

Mr. Frank W. Smith, Vice President, United Electric Light & Power Company.

DEAR MR. SMITH: In reply to your memorandum of January 26th, would say that the question of an investigation of troubles on 60 cycle tie lines has been and is receiving most thorough consideration.

I am summarizing to you what has been accomplished up to date as follows:

On November 24th I made the recommendation that the 60 cycle tie feeders be subjected, one at a time, to a three phase, 30,000 volt test for thirty minutes. The Underground Department considered it at the time unwise to [fol. 660] apply the test as they had considerable work on hand and also on account of season of the year.

At the same time I started a thorough investigation of the methods of making joints. Joints were tested incorporating the suggestions and ideas of the following parties:

1st—The New York Edison Company

2nd—The United Electric Light & Power Company

3rd—The Safety Insulated Wire & Cable Company.

In conjunction with all of these tests, the use of the vacuum process filling was adopted in parallel with filling without vacuum.

The results of the numerous tests have indicated that:

(a) Paraffine filler creates voids due to contraction, also dissolves the impregnating oil of the cable insulation.

(b) Waxy compound fillers like hydroline, ozonite, etc., make a good binding and penetrating filler, but are to be poured at high temperatures. The hot compounds, especially in opposition to the pouring holes, may damage the cable insulation. These compounds would also create air voids.

(c) Tarry and pitch compound fillers do not make good binding compounds to seal the interstices between the paper [fol. 661] edges and also are subject to the objection of re-

quiring a high pouring temperature and creating air voids as in the second case.

In view of these difficulties I have been starting experiments along a new line of study based on the principle of filling the joint made without any insulation, with a liquid compound which would fill the complete splice which is then subjected to moderate external temperatures so as to chemically change the constitution of the liquid compound into a solid compound. This process for the first test required too long a period for the chemical change. Other tests are being carried out by substituting mixtures that will solidify within a shorter period of time. Along with these tests other experiments are also carried out by substituting putty mixtures of the above compound which can be applied with a trowel, so that every space is filled, after which the compound is solidified by application of heat.

It is unnecessary to state that the carrying out of the above experiments requires considerable time.

Parallel with experiments above mentioned, several conferences were held with the representatives of the Boston, Chicago, Detroit and the New Jersey Public Service Companies, all of which have had experience and troubles with high tension cables or joints or both.

Oscillograph Tests

During the last trouble on feeder No. 253, for the first time in the history of our operation of high tension systems, [fol. 662] we have had visual evidence of manifestation of surges on our system.

Cable 253 was tested from 201st Street testing set with 20,000 volts applied between two conductors and one conductor and ground and sparking occurred across the terminal of the disconnecting switches in Waterside Station, the sparking distance being 5" which is equivalent to a minimum of 65,000 volts applied voltage. After this occurrence we promptly arranged to have oscillograph charts taken to determine whether the surge was caused by higher harmonics in the wave form of the testing current or to other troubles. The oscillograph has shown that the wave form is approximately a correct sine wave which fact would eliminate the possibility of troubles being caused by higher harmonics in the testing current. The trouble must, there-

fore, be due to rupture of insulation on the cables, these ruptures being probably due to arcing grounds causing surges along the cable which, as indicated above, must be in the order of at least 65,000 volts. An oscillation of 85,000 volts apparently has been recorded on the oscillogram.

Method of Testing

Mr. Lawrence has brought out the point that possibly the method of testing between two conductors and conductor and ground would introduce a larger capacity in the circuit which would exaggerate surges if surges occurred and he, therefore, recommended to test the cable three phase, applying 25,000 volts. A test made under these conditions [fol. 663] still shows surges as indicated by fluctuations of the voltmeter, but no sparking occurred at the terminals of the disconnecting switches at Waterside as in the former case.

Conclusions

At the present writing I would summarize the conclusions of this investigation as follows:

1st—The paraffine filled splices have inherent voids.

2nd—The first of these originally broke down and when the testing voltage between two conductors and conductor and ground was applied, the next weak point broke down, causing surges and developing quite a number of weaker points on several other joints on the cable so that in a great measure troubles may have been caused by the testing as well as the constant application of the normal voltage in service.

Recommendations

At the present moment I would outline tentatively the recommendation that I probably shall make at the completion of all the investigations under way, as follows:

1st—Re-make all joints in an improved manner as it will be determined by the investigation.

2nd—Substitute the present grounding in Waterside Station with an artificial ground on the transformers reconnected delta with a teaser transformer "T" connected and with the neutral brought out from the winding of the teaser,

[fol. 664] this grounding being made both at Waterside and 201st Street ends of the cable.

3rd—In high voltage testing of cable, apply only three phase voltages of, say, 30,000 volts.

4th—When the high voltage is applied from the 201st Street testing set, connect also to the cable under test the Waterside Station testing transformer, with its neutral grounded, so that under test the cable will have the neutral grounded at both ends of the cable.

I am pushing the work along these lines as hard as possible, but the character of the study is such that, as you will appreciate, the final results cannot be expected in very short time.

Yours very truly, —— ——, Chief Electrical Engineer.

PT/RL.

DEFENDANT'S EXHIBIT R

The New York Edison Company, Irving Place and Fifteenth Street, New York.

In re 22,000 Volt Cable Splice

February 23, 1915.

Mr. Frank W. Smith, Vice President, The United Electric Light & Power Company, 130 East 15th Street, New York City.

DEAR MR. SMITH: I submit a recommendation for the adoption of a form of cable splice which I have developed for high tension cables.

[fol. 665] In my memorandum to you of February 2nd I summarized the results of the extensive investigation on the methods of making joints, carrying out the suggestions of our Companies and the Safety Insulated Wire & Cable Company. In that report I stated that, while some of the splices tested lasted as long as 158 hours, still there was in all cases such a lack of uniformity of results that we did not feel we had found the right solution.

Two weeks ago I mentioned to you and Mr. McCoy the hopes I entertained of having reached the solution by a

form of joint which consists of making the splice by insulating it in the usual way, but wrapping around its outside insulating jacket a copper gauze, which is carefully held at the ends under the edges of the lead sheath, carefully pressed down, and by a lamp wick; the splice so made is then enclosed in a special sleeve, which is then filled under vacuum with a very light oil which penetrates and fills not only the insulation and voids in the splice, but also the disturbed ends of the cable.

The results of the tests on splices so made are as follows:

Hours 3 phase, 50,000 volt test

Series Number	Splice full of oil	Splice drained	Total hours	Results
23	78	17	91	O.K.
24	65	168	233	"
27	26	132	158	"
28	50	58	108	"

[fol. 666] With cables not operating at such high potentials as the New Haven service requires, it may still be desirable to adopt the same principle of filling the splice with a light oil and providing means for retaining the oil therein and preventing it from oozing out if perchance the annular space around the insulation in the splice is drained of, and does not retain in full, the light oil. For this purpose I have also tested two splices made without the metal armor and wick, but having the light oil in the outer space replaced by a heavy oil. The results of these two tests on series Nos. 25 and 26 after 179 hours test show them O. K., but some draining is now being done to see what the results will be.

In similar manner a sample splice furnished by the United Company was submitted to test with the other splices and the results were:

Splice full of oil	64 hours
Splice drained	Failed after 10 minutes

In view of the above results, I think that you are in a position to act favorably on the above recommendation.

Yours very truly, Philip Torchio, Chief Electrical Engineer.

PT D.

[fol. 667] DEFENDANT'S EXHIBIT S

Boston, Chicago, Detroit, Minneapolis, Pittsburgh, St. Louis, Philadelphia, Atlanta, Seattle

Mr. Kirke

Metropolitan Device Corporation

Manufacturers of the Murray Protective Devices

1250 Atlantic Avenue, Brooklyn, New York

May 23rd, 1927.

Mr. J. C. Parker, Vice-President, Brooklyn Edison Company, 360 Pearl Street, Brooklyn, N. Y.

DEAR MR. PARKER: Will you make your own tests of the Metrolatum Filled High Tension Cable Joint?

Prove to your own satisfaction that this joint is stronger than the cable itself.

A copper gauze stocking the patented feature is what distinguishes the Metrolatum Filled High Tension Cable Joint. This stocking acts as an eleterostatic shield and distributes equally the electrical stresses around the conductors.

Cable engineers are in agreement that the use of mineral oil compound for filling the cable joint, similar to that used for impregnating the cables, is beneficial, adds life to the cable and guards against failure. Metrolatum which is used for filling this High Tension Cable Joint which we manufacture, is a high grade mineral oil compound. It [fol. 668] has high dielectric strength (we guarantee 25,000 volts per 1/10 inch gap at 120° F.), and low dielectric loss.

One of the figures in a recent test, was an eight hour strain of 160,000 volts. The joint was made on three conductors 350,000 cm sector cable with 20 x 10 inches of in-

64

sulation.

If we were not sure that the Metrolatum Filled High Tension Cable Joint has decided advantages, do you think we would make this offer?

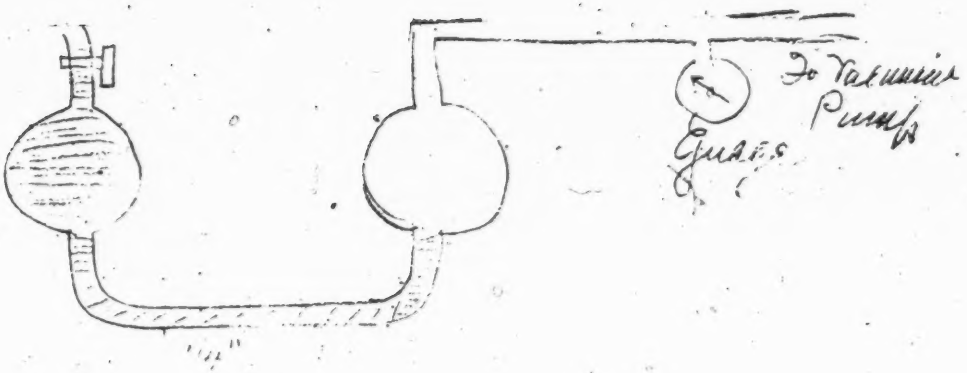
Very truly yours, Metropolitan Device Corporation,
J. B. Murray, Vice President.

JBM:MGD.

(N)

669

DEFENDANT'S EXHIBIT T



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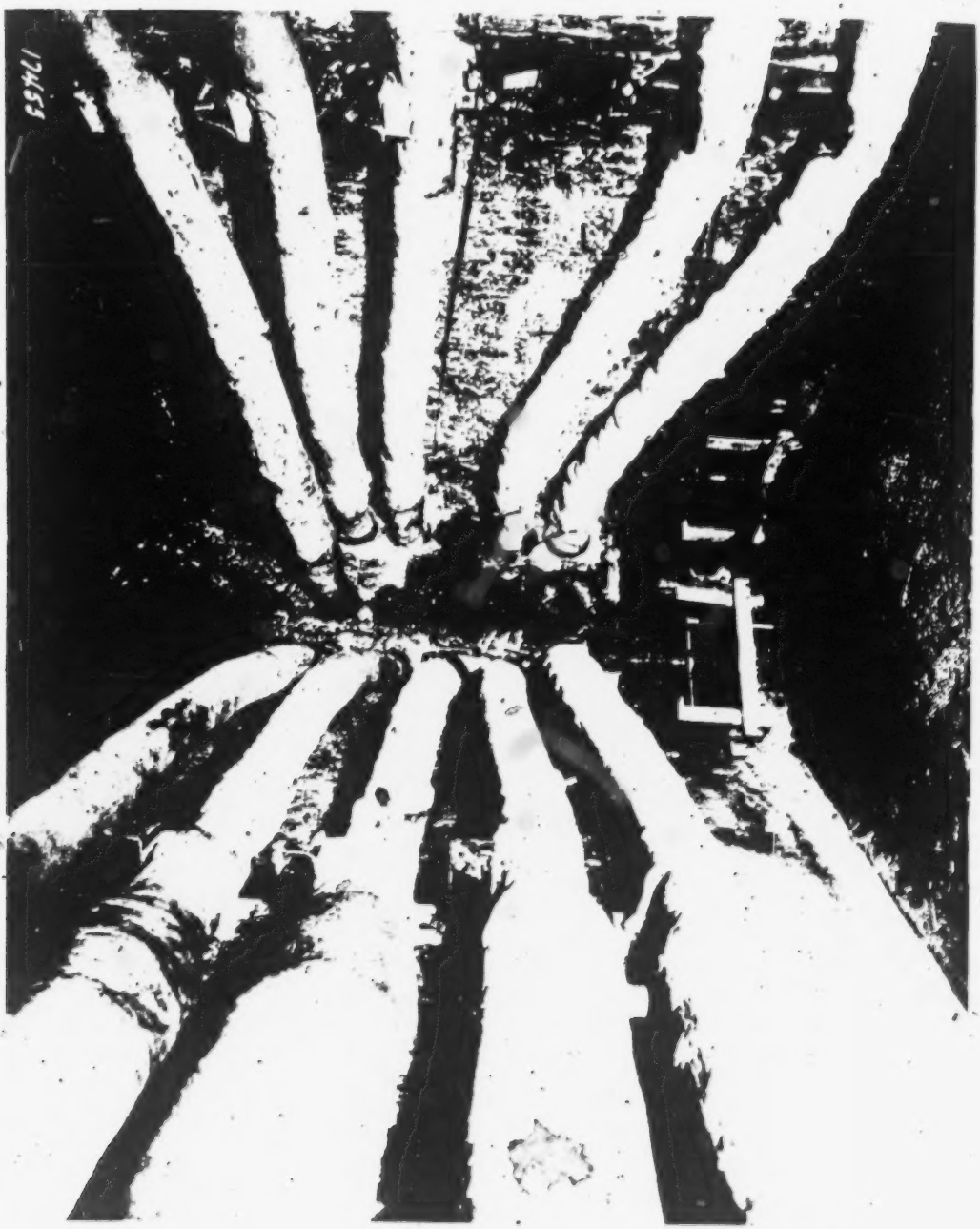
DEFENDANT'S EXHIBIT U



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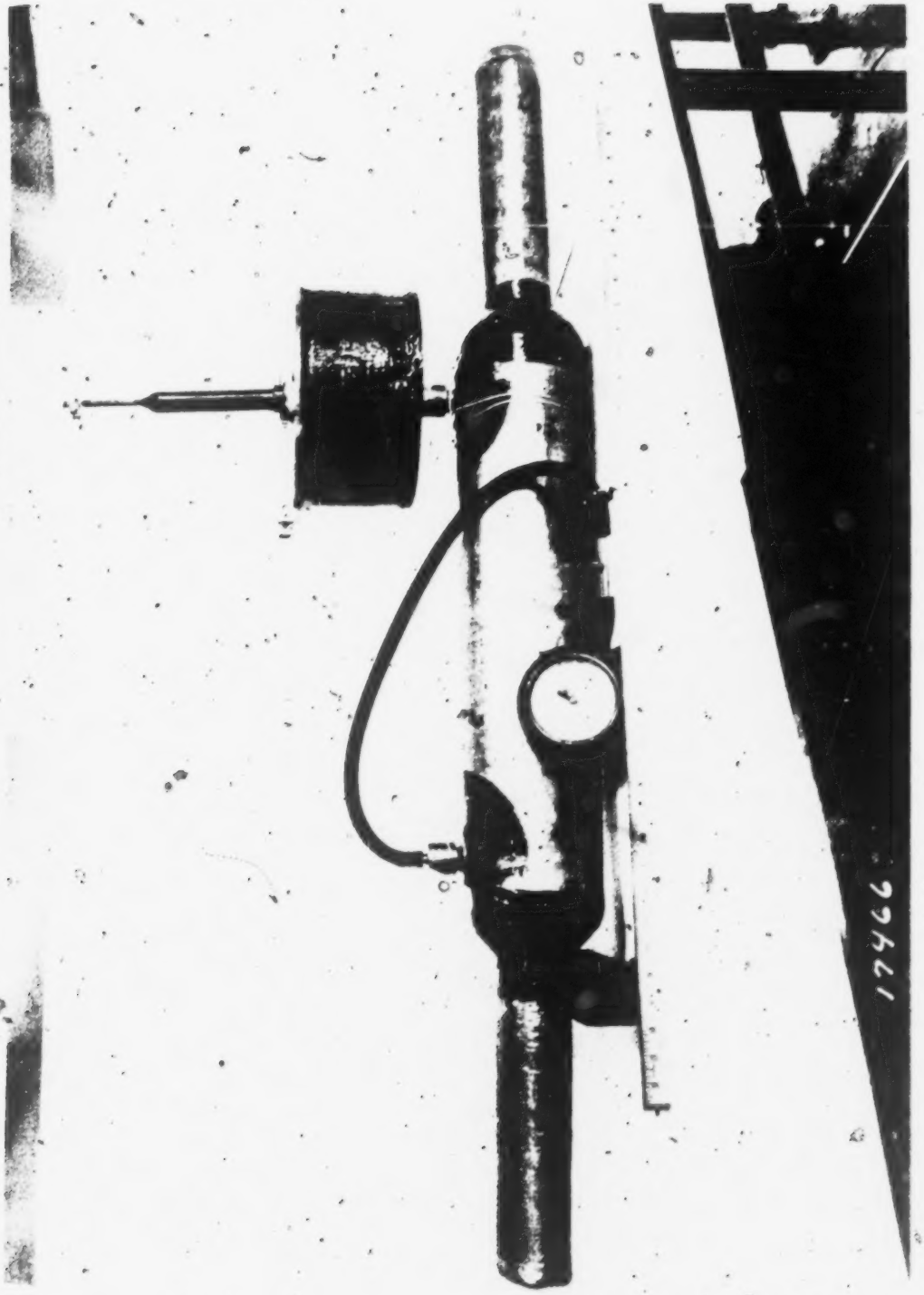

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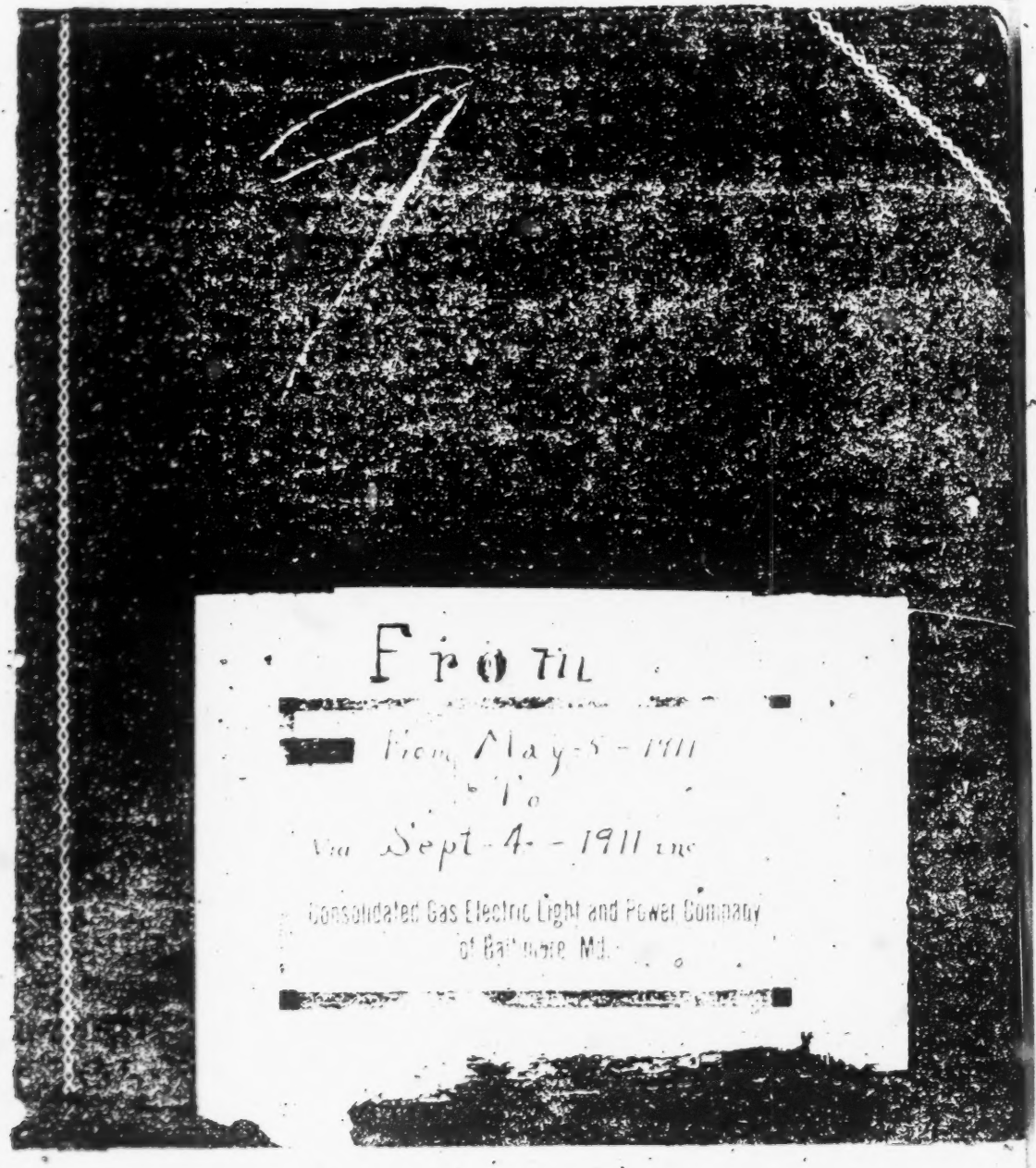
DEFENDANT'S EXHIBIT W

672



100

[illegible] Dec 27 1911

[illegible] Rotary running on #1-5-53 cable
[illegible] started #5 Rotary
[illegible] started [illegible] Rotary
[illegible] Shut down #3 Rotary
[illegible] Shut down #2 Rotary
[illegible] Shut down #3 Rotary
[illegible] Started #5 Rotary
[illegible]

Night.

#7-4-5 Rotary running on 1-53-5 cable
5:30 Shut down #2 Rotary
5:24 Put out #6 cable
5:24 " " #24 cable
12:00 Shut down #5 Rotary
6:30 Started #5 Rotary down #[illegible] Rotary

160/1600

[illegible] Aug 15 1911

[illegible] #3-5 Rotary running on #1-5-53 cable
7:30 Started #2 Rotary
10:55 Started #3 Rotary
10:55 Shut down #3 Rotary
1:50 Started #4 Rotary
1:50 Shut down #6 Rotary

[illegible] 39239

Night

#3-4-5 Rotary running on #1-5-53 cable
5:20 Shut down #3 Rotary
[illegible] Shut down [illegible] Rotary

Conc Dept installing Trans Williston on O & D. C. Feeders
glove men refilling pot heads on
#24-25 Cable disconnected
Conc Dept Changing Trans. Connections
on #1 Getting the Feeder Cables
ready for cutting on east end of
plant & pulling same in ducts

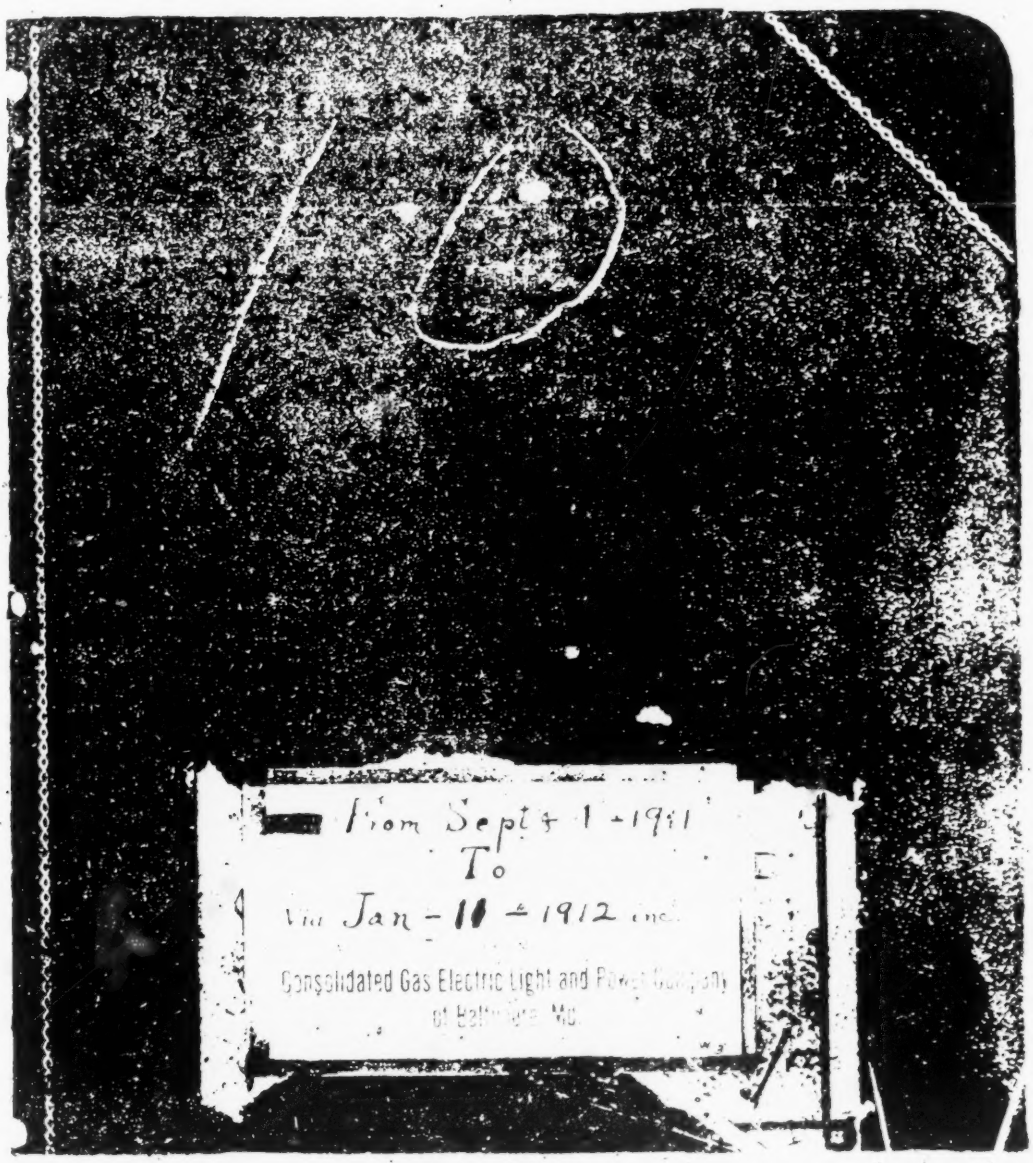
THURSDAY JULY 27, 1911

Load Dispt took watthours of #1-3
B & O. D. C. Feeders and installed single
watthours for #1-2-3 Feeders
Watthour #17874 Constant 10
Took readings off of old watthours
and made note of same also
initial reading of new watthours
Used men changing pot heads
on #24-25 cables

FRIDAY JULY 28 1911

While getting ready to cut #24-25
cables with 3600 volts one of them of
#1 Rotary became ruptured.
Located #25 & 2 cable the same
tested O.K. with 15000 V to ground, and
used #1 Rotary — Phased out #25 cable &
Connected same so as to be used in
emergency.
Conc Dept Connected temporally lights
for Galley House
Conc Dept pulling #25 cable on East end
Cable pulling crew on Trade

538
674


From Sept 1 - 1911
To
Jan - 11 - 1912 inc
Consolidated Gas Electric Light and Power Company
of Baltimore Md.

SATURDAY OCT 14 1911

Night.

#1-3-5-6 Rotarys running on #1-5-53 cab
5[10] Pulled out #736 feeder switches.
5[35] Pulled out #730 feeder switches.
10[05] started #4 rotary.
10[25] shut down #6 rotary.
10[75] shut down #1 rotary.
10[25] Closed #730 feeder Switches.
11[25] shut down #5 rotary
11[25] closed #736 feeder switches.
12[25] shut down #3 rotary
6[20] A.M. Cut out #4 and 53 cables
6[20] A.M. Cut in #3 and 51 cables

K. 1. 2935 V.O.

SUNDAY OCT 15 1911

Day #1 Rotary running on 3-5-51 Cables

Night.

#1 Rotary running on #3-5-51 cables
6[30] Started #1 rotary.
6[35] shut down #4 rotary.

K.V. 1308 3.

MONDAY OCT 16 1911

Day #1 rotary running on #3-5-51 Cable
7[00] started #2 rotary
7[25] started #6 rotary
9[15] Cut in #21 Cable
9[45] Cut out #21 Cable
10[00] Cut in #24 Cable Cut out #23
11[00] Cut out #24 Cable Cut in #23
11[15] Cut in #1 Cable Cut out #5
11[25] Cut out #1 Cable Cut in #5
11[40] Cut in #1 Cable
3[00] Cut in #53 Cable
3[00] started #3 rotary
5[00] Cut out #3 cable

W 34214

5[00] Cut out #5 cable

DEE E.R.W. (4). 51 675

SATURDAY OCT 14 1911

SUNDAY OCT 15 1911

MONDAY OCT 16 1911 (Wilf Tracy came to work for first time after illness.

Conr Left working on cartel wiring and Battery house work.

Relieved new air suction cleaner from Westport. (Mr. Cragan)

Filled # 23 - 24 - 75 - 5 - / Cable is wash. oil. U. G. - ✓

Night

= 5-5 - = 5 - 5 Rotarys running on # 1-5-53 cables
2 Shut down #4 Rotary
6 Shut down #6 Rotary
10 20 Shut down #5 Rotary
1 20 Shut down #3 Rotary
6 39 Put # 36 feeder in

526-32 4 11

WEDNESDAY NOV 8 1911

Day.

#3 6 Rotary running on # 1-5-53 cables
10 05 started # 4 rotary
10 52 started # 6 rotary
8 42 Cut in # 3 & # 51 cables.
8 42 cut out # 1 & # 53 cables.
10 45 cut in # 24-27 cables.
10 45 cut out # 23 cable.
10 50 cut in # 23 cable.
10 50 cut out # 24-27 cables.
10 53 cut out # 1 cable at Westport.
10 53 cut in # 1 cable at Westport.
3 50 started # 5 rotary.
3 52 started # 2 rotary.
4 30 started # 1 rotary.

J.W. 1970.

WEDNESDAY NOV 8 1911

Night

#1-2-3-4-5-6 Rotarys running on 3-5-51 ca
6 05 Shut down #1 Rotary
6 12 Shut down #2 Rotary
6 22 Shut down # 6 Rotary
10 55 Shut down # 5 Rotary
11 53 Shut down # 3 Rotary

A.W. 1963

Cons dept working in switch board in connection with new Battery. ~~Grant~~ Also running Cable in Connection with Battery.

WEDNESDAY NOV 8 1911

Cons. Dept. working on switch boards in connection with new battery. also running pipe for lighting service and control wire. Underground Dept. refilled pot heads on #1-2-3-4-5-6 cables. Burriss & Lang raised voltage on system 2 Volts + & — sides.

WEDNESDAY NOV 8 1911

Night Cons Dept working on switch boards in connection with Battery. Also running pipe for lighting service & Control wire.

THURSDAY NOV 9 1911

Day Cons Dept [illegible] in connection with Battery.

543

96

FRIDAY NOV 24 1911

Night.

#1-2-3-4-5-6 Rotarys running on #1-5-53 cable
5:33 Shut down #1 Rotary
6:15 Shut down #2 Rotary
6:32 Shut down #6 Rotary
10:-- Shut down #3 Rotary
11:51 Shut down #4 Rotary
6:30 Started #1 Rotary
6:30 Shut down #5 Rotary

Sgt. 345-93

Day.

SATURDAY NOV 25 1911

#1 Rotary running on #1-5-53 cables
7:40 " started #2 Rotary
10:30 " started #6 rotary
10:35 " Cut in #2-27 Cables
10:35 " Cut out #23 cable
10:42 " Cut in #23 cable
10:42 " Cut out #24-27 cables
11 " Cut out #3 cable at Westport.
11:30 " Cut in #3 cable at Westport & McC
11:30 " Cut out #1 and #1-51 cables.
12:07 " Cut in #1 and #1-51 cables.
12:07 " Cut out #3 cable at McC
12:20 " Cut in #3 and #51 cables.
12:20 " Cut out #1 cable.
1:05 Cut in #21 cable
2:05 Cut out #21 Cable
3:20 Pulled #7 36 feeder switches.
4:40 " Started #3 rotary.

Sgt. 34689.

FRIDAY NOV 24 1911 DEF EX. W© 97

night

Cons dept working on water mains in McClellan st Making Connections for Battery house

Blowed out & cleaned #6 Battery

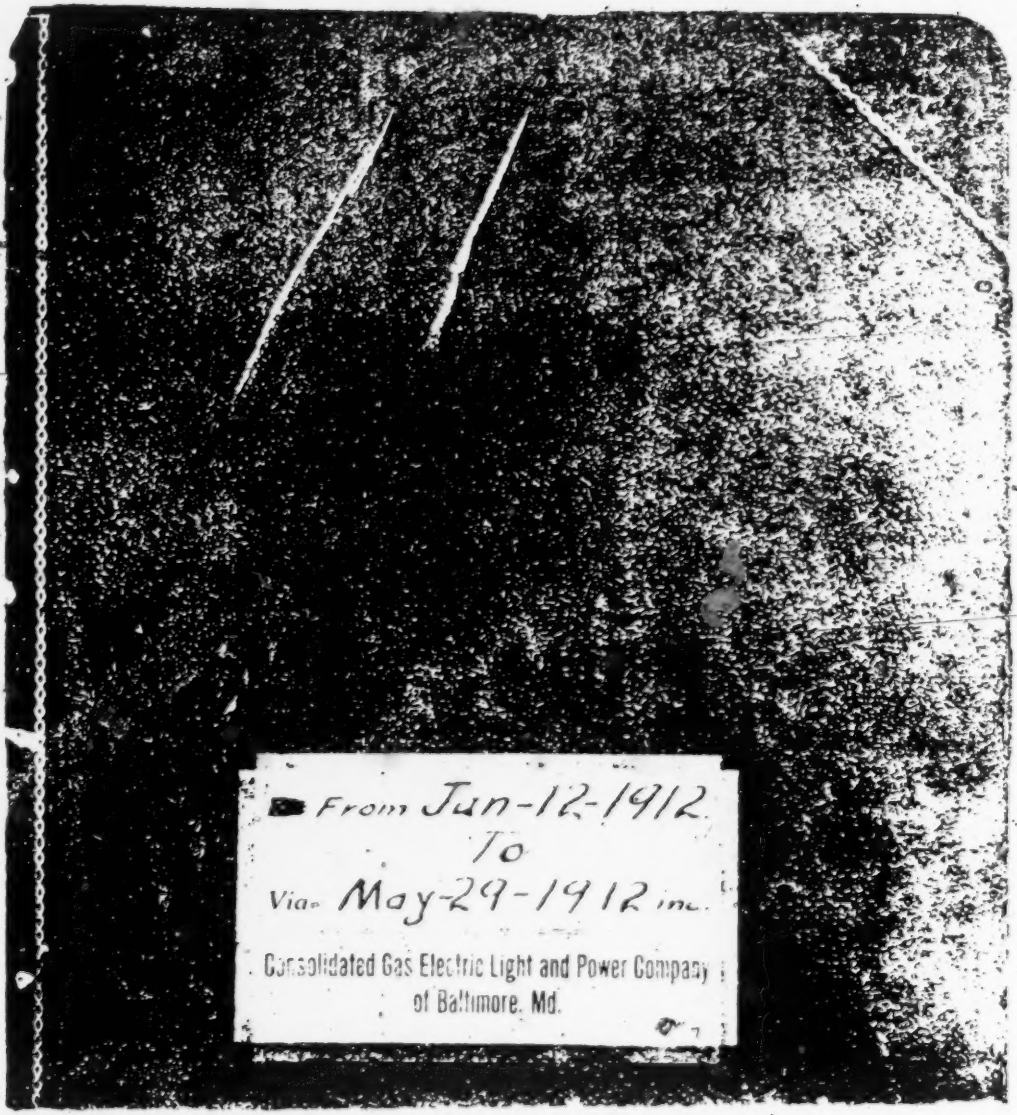
SATURDAY NOV 25 1911

Simonds and helper filling pot heads on #24-25-23-#1 and #1-5.1 #3 and #5 3 cables

Mullin working in field leads on #3 and #4 rotors

Cons. Dept. working on control wire. Ect. also put new arm rings on #5 rotary bearings.

545
678


From Jun-12-1912
To
Via May-29-1912 inc.
Consolidated Gas Electric Light and Power Company
of Baltimore, Md.

FRIDAY FEB 16 1912

#3 Started running on #1 & #3 cables
7[30] Started #6 rotary
8[10] Cut in #6 cable on "A" bus
8[15] Cut out #13 & #14 feeder switches
8[25] Cut in #7 cable on "A" bus
9[30] Cut out one of "A" bus in on "B" bus
9[45] Cut in 2 cable in on "A" bus
11[20] Cut out #1 & #3 cables
11[40] Cut in 1 & #3 cables
12[50] Cut out #5 cable
1[00] Cut in #5 cable
1[25] Cut out #1 cable
1[35] Cut in #1 cable
2[00] Cut in #13 feeder
2[05] started #5 rotary
3[30] closed #14 B.C. feeder switch
3[35] cut out #7 cable

Kn. 39369

FRIDAY FEB 16 1912

Night #3-4-5-6 rotaries running on #1-2 cables
5[30] Cut out #21 and 22 cables
6[15] Shut down #6 rotary
8[00] Pulled switches on #13 & 14 feeder
11[40] closed switches on #13 feeder
10[45] Shut down #5 rotary
11[55] Shut down #4 rotary
6[20] Started #1 rotary
6[30] Shut down #3 rotary
6[45] Started #3 rotary
7[00] Cut in #21 cable on "A" bus
7[10] Cut in #22 cable on "A" bus

Kn. 39413

FRIDAY FEB 16 1912

Battery floating on #2 bus
Cons Dept. working in battery house.
Indg Dept. changing #703 & #704 B & O
feeders from operating room to
basement of battery house. also #703 feeder
was pulled out & #703 feeder.
Inds Dept refilled pot heads of
#1-B-5-7-7A-2 cables.
Cons Dept removed B & O. D. C.
Wattmeter to basement of battery house
but no #703 feeder on new panels
in battery house.
but no #704 feeder B & O on new
panel in battery house.

FRIDAY FEB 16 1912

Night Battery floating on #2 bus.
Cons and underground dept
working on #708 feeder in
battery house basement.

THURSDAY MAR 14 1912

Night

#3-4-5-6 Rotarys running on #51-53 Cables
5[40] Cut #V3 cable on B Buss with #51-53 cables
5[45] Cut out #V1-V2-V4-V5 cables
6[05] Shut down #6 Rotary
7[45] Cut in #V1-V2-V3-V5 cables on A Buss
7[45] Cut out #V3 off B Buss
10[17] Cut in #V3 cable on B Buss
10[47] Cut out #V1-V2-V3-V5 cables off A Buss
10[50] Shut down #5 Rotary
11[50] Shut down #4 Rotary
6[30] Started #4 Rotary
6[30] Shut down #3 Rotary
6[50] Started #5 Rotary

K.W.H. V5900.

FRIDAY MAR 15 1912

Day #2-3-4-5-6 Rotary running on #51-53 cables
7[35] Started #6 Rotary
8[45] Started #3 Rotary
9[30] Started #2 Rotary
10[20] Cut out Cable
10[35] Cut in #1 Cable Cut out #3
10[55] Cut in #3 Cable
1[15] Cut out #1 Cable
1[25] Cut in #1 Cable
1[40] Pulled #35 Feeder
2[25] Put in #35 Feeder

K.W.H. = 5187

FRIDAY MAR 15 1912

Night #2-3-4-5-6 rotarys running on #51-53 cables
5[25] Shut down #2 rotary.
6[15] Shut down #6 rotary.
10[50] Shut down #3 rotary.
12[50] Shut down #5 rotary.
6[30] Started #1 rotary.
6[30] Shut down #4 rotary.
6[45] Started #2 rotary.

K.W. V6140

680 THURSDAY MAR 14 1912

Night Battery floating on # v Bush

FRIDAY MAR 15 1912.

Day Battery floating on # v Bush
Exc. Storage Battery Co's men
working in Victor
Simmons Cat leads on # 3 v. 132 of 725 Cable
Eagle Ground Dept. Charging # 7, 8 & 9 G.T.C. Testing
to permanent position.

FRIDAY MAR 15 1912

Night Battery floating on # v Bush
Meter dept men testing G E & C.
watt meter.

550
112

FRIDAY APR 25 1919

Day
#3-4-6 Rotards running on #5 #53 cables
753 #4 started #6 Rotary
935 Cut in #24 #27 Cables
935 Cut out #23 cable
915 Cut in #23 cable
915 Cut out #24 #27 cables
Cut out #1 Cable
Cut out #3 Cable
Cut in #1 Cable
Cut in #3 cable
Cut in #24 #27 cables
Cut in #5 Cable
Cut out #24 #27 Cables
Cut out #2 Cable

Night K.W. 38009.

FRIDAY APR 26 1919

#3 #6 Rotary running on #5 #53 Cable
520 Started #5 Rotary down #6
10?? Shut down #5 Rotary
1153 Started #1 Rotary down #4
1247 Shut down #3 Rotary
??? Started #1 Rotary
1153 Cut out #1-57 #53 Cables
Cut in #5 #1-53 Cables

K.W. 37619

SATURDAY APR 27 1919

Day #1-2 Rotards running on #51 #52 Cable
815 Started #6 Rotary
910 Started #4 Rotary
913 Started #5 Rotary
914 Shut down #1 Rotary
91? Shut down #2 Rotary

K.W. 33811

551
681
113

FRIDAY APR 26 1912

Night: Battery floating on #2 bus.
Day. Construction dept working on battery house. Also changing Metal of #5 Tray Also on Panels for regulator and for compressed air line. Inside Room. Dept pulling cables. Underground man examined for leads on H.T. cables. ✓

FRIDAY APR 26

Night Battery floating on system

SATURDAY APR 27 1912

Day Battery floating on #2 bus
Construction working on battery house
Also on Panels for regulator also
on compressed air line, and
changing for regulator.
Night Signal men working on D.C.
cables in manhole
& vaulted #4 & 7 Bell

SUNDAY MAY 5 1912

MONDAY MAY 6 1912

MONDAY MAY 6 1912

TUESDAY MAY 7 1912

SUNDAY MAY

Night Battery floating on system

MONDAY MAY 6 19 2

Day Battery floating on system
Gang dept working in battery house Also on poles for regulators and on pipe line for compressed air
Mr. Glover men filling 187 heads of H.T. Cabled.

MONDAY MAY 6 19 2

Night Battery floating on System

TUESDAY MAY 7 19 2

Day Battery floating on system.
Gang dept working in battery house Also running wire for regulators
Underground dept refilling port heads of following cabled
#51-53-123.22

WEDNESDAY MAY 7 1917

WEDNESDAY MAY 8 1912

WEDNESDAY MAY 8 19-7

TUESDAY MAY 7 1912.

Night Battery floating on system
Charging Battery from 12 15 to 1 05

WEDNESDAY MAY 8 1912

Day - Battery floating on system
Cont dept working on Battery house
& regulator, conduction and
running pipe line for compressed
air
Mr Lewis running filling flat head
of #2 H. T. cable.
Testing with #2 H. T. Cable Battery
Booster and #2 Rotary.

WEDNESDAY MAY 8 19[illegible]

Night Battery floating on system

12

From May-29-1912
To
Via Oct.-1-1912 inc.

Consolidated Gas Electric Light and Power Company
of Baltimore, Md.

SATURDAY AUG 24 1912

Day. #3 Rotary running on #51+53 cables
7[05] Started #4 Rotary
7[45] Started #5 Rotary
1[40] " cut in #24 + 27 cables
1[43] " cut out #3 cable.
1[44] " cut in #23 cable.
1[--] " cut out #24 + 27 cables

KW 3192

SATURDAY AUG 24 1912

Night. #2 + 3 + #4 Rotary running on 51+53 Cables
7[40] pm Cut in #705 Feeder
7[02] " Started #6 Rotary down #4.
7[45] " Cut in #21+22 Cables on Arc
10[50] " Shut down #6 Rotary
12[50] " Cut in #726 feeder.
11[07] " Cut out #21 + #22 Cables.
12[10] am Shut down #8 Rotary

KW 2665
Day.

SUNDAY AUG 25 1912

#2 Rotary running on #51+53 cables
27 Cut out #5 cable

KW 8259

Night.

SUNDAY AUG 25 1912

#2 Rotary running on #51+53 Cables
7[40] pm Cut in #705 Cable
6[57] " " Cut in #5 Cable
7[02] " Started #3 rotary
10[53] pm Cut out #3 rotary
12[10] " Cut out #705 Feeder
KW 6[30] " Started #3 Rotary down #1

KW 11129

Day Battery floating on system.
Gons dept working & the Pulling house, also on parts of #0 rotary.
Mr. Eddicords men moving parts of #1 into station.
Mr. Glover Man examining & filling Pot heads.

SATURDAY AUG 24 1912

Night. Battery floating on system

Day.

Battery floating on system

SUNDAY AUG 25 1912

Battery floating on system

[illegible] #5 [illegible] running on #5 + 53 cable
[illegible] started #3 rotary
[illegible] started #6 rotary
[illegible] cut out #1, 3 + 5 cable
[illegible] cut in #1, 3 + 5 cable
[illegible] started #2 rotary
[illegible] closed #2 + 22 cable [illegible] on "A" bus
[illegible] opened #2 + 22 cable
[illegible] [illegible] [illegible]

KW - 5345

WEDNESDAY SEP 18 1912

#2-4-5 + 6 rotaries running on #5 + 53 cable
5 45 cut in #2 cable
5 52 cut out #3 + 33 + 53 - 53 cables
6 00 cut in #705 feeder 6 05 Shut down 6 rotary
6 11 cut in 3 #53 + 3-53 feeder
6 12 cut out #22 bus
6 25 cut in 21 + 22 cables on A bus
6 [illegible] cut out 21 + 22 cables
6 40 cut in 21 cable on B bus
10 45 Shut down #5 rotary
12 00 cut out 705 feeder
12 02 cut out 21 cable
12 15 Shut down 5 rotary
6 32 Started #5 rotary Shut down #4 rotary

KW 33567

THURSDAY SEP 19 1912

Daily Battery floating on system. Gen'l dept working in battery house, also on #1 portable M. Types of Underground dept. examined Pot heads of following cables #1-2-3-5-21-22-23 2-21 & 26 cables and put oil in where needed.

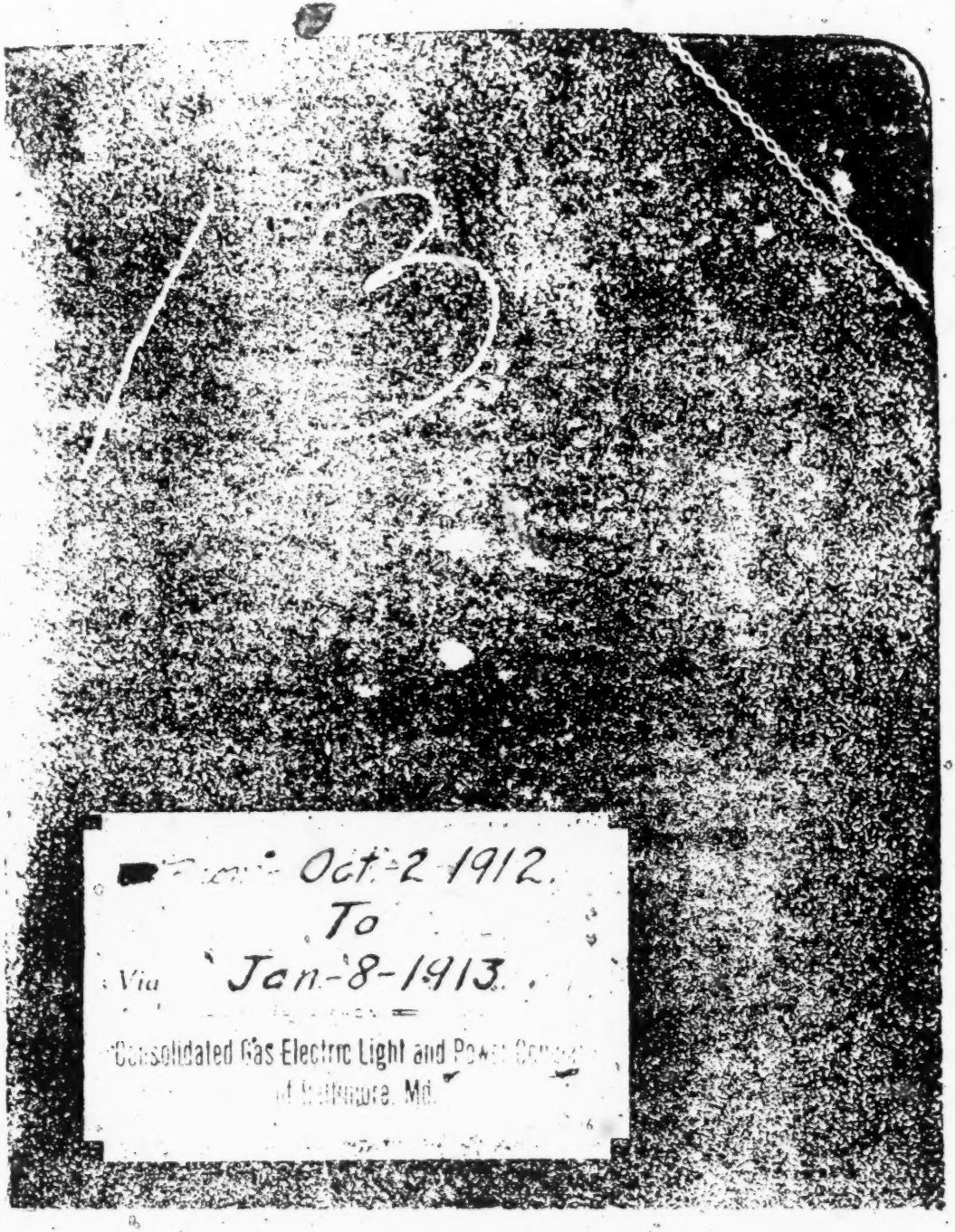
WEDNESDAY SEP 18 1912

Battery floating on system

THURSDAY SEP 19 1912

Battery floating on #2 buss Gen'l dept working on new rotary

Charged #- - cell at 1000 amperes rate from 12 P.M to 4 P.M


Oct-2 1912.
To
Via Jan-8-1913.
Consolidated Gas Electric Light and Power Co.
of Baltimore, Md.

SUNDAY OCT 6 1912

Night.

#1 Rotary running on #51+53 cables
6 21 Fed #2 + #22 cables on "A" bus.
6 21 Started #1 rotary.
6 25 Closed #79 feeder switches
6 25 Closed #72 feeder switches
10 30 Shut down #1 rotary.
12 30 Cut out #21+22 cables

All. 32 :/

MONDAY OCT 7 1912.

Day. #2 Rotary running on #51+53 cables.
7 00 Started #3 Rotary
7 45 Started #6 Rotary
9 22 Cut in #21+22 cables on A bus
9 40 Cut in #23 cable on A bus cut on B
9 41 Cut in #25 cable on A bus
9 58 Cut out #25 #21+22 cables
9 58 Transfered #23 cable to B bus
10 02 Cut in #24 cable on B bus
10 02 Cut out #51 cable
10 12 Cut in #51 cable
10 12 Cut out #53 cable
10 22 Cut in #53 cable
10 22 Cut out #23 cable
12 27 Cut out #3 #53 +3-53 cables for insulation
12 27 Cut in #3 #53 +3-53 cables
2 11 Cut in #24 cable on B bus
2 11 Cut out #23 cable
2 18 Cut in #23 cable
2 18 Cut out #24 cable
2 22 Cut out #5 cable
2 22 Cut in #5 cable
2 32 Cut in #21 cable on B bus
2 32 Cut out #3 #53 +3-53 cables
K.W. 2 34 Cut in #3 #53 +3-53 cables
37404. 2 37 Cut out #1 #51 +1-51 cables
3 25 Cut in #1 #51 +1-51 cables
3 26 Cut out #3 #3-3 +3-53 cables
3 32 Cut in #3 #53 +3-53 cables
3 32 Cut out #21 cable
4 20 Started #4 Rotary

to refill batteries.

SUNDAY OCT 6 1912

Night

Battery floating on system.

MONDAY OCT 7- 1912

Day

Battery floating ~~on system~~.
Comd Dept working on #1 Rotary Panel
#55 oil switch
Underground Dept pulling in #55 cable
Underground Dept inspecting pot heads of high tension cables.

THURSDAY, OCT 24 1912

#1 #2 #4 #5 #6 Rotary running on
#5 and #53 cables
[illegible] down #1 Rotary
[illegible] down #6 Rotary
[illegible] down #2 Rotary
[illegible] #2 and #28 cable
[illegible] down #7 Rotary
[illegible] 05 and 721 feeders
[illegible] #2 Rotary down #4 +
[illegible] #3 Rotary

THURSDAY OCT 24 1912

Battery floating on system

FRIDAY OCT 25 1912

Battery floating on system

Lens Dept working on battery equipment

Lens Dept extended A & B bus to #55 cable oil switch

Underground Dept put oil in #5 cable & set head

566
50

SUNDAY NOV 3 1912

Day

#4 Rotary running on #51 + 53 cables.
10[09] pm cut out #3, 53 + #3-53 cables for maintenance
12[26] cut in #3 53 + #3-53 cables
KW 2[45]

Night

SUNDAY NOV 3 1912

#4 Rotary running on #51 + 53 cables
5[22] Started #2 Station
5[29] closed #705 feeder switches
6[10] Closed #72 feeder switches
10[45] shut down #4 Rotary
2[00] Pulled #705 and #72 feeder switches

KW 13727

Day

MONDAY NOV 4 1912

#2 Rotary Running on #51 + 53 cables
7[02] Started 3 feeders
7[55] Started 1 feeder
8[24] cut in 2 #4 cable on system + cut out #1 51 + 53
9[43] cut in 151 + 153 cables
9[45] cut out #3 53 + 3-53 cables
11[19] cut in #3 53 + 3-53 cables
11[24] cut in 2 #4 cable on [illegible]
12[48] cut out [illegible]
2[00] PM cut in #72 feeder
3[45] Started #1 Rotary
4[40] cut in #2 cable
4[52] cut in #1 cable

KW 4[05]

690
51

DEFEx W(3)

Day

SATURDAY NOV 2 1912

Battery floating on system

made insulation test on 53 bells

SUNDAY NOV 3 1912

Battery floating on system

Day

MONDAY NOV 4 1912

Battery floating on system

tone D-F-A working on Rotary

U. S. Dept refilled 3-53 - 1-51 Fitchs.

tested Rotary with 56 ~ one bell

from 1 P.M. to 12 P.M.

[illegible] #2 #4 #5 #6 [illegible]
#51 and #52 and #55 cables
5[illegible] Shut down #2 Rotary
6 00 Started #2 Rotary
6 00 Shut down #1 Rotary
6 30 Shut down #6 Rotary
6 30 Out #4+5 Sharp [illegible]
[illegible]
7 [illegible] Out #4 #55 cable in 10. Out [illegible]
[illegible] in #55 cable on 1 hour
7 [illegible] Out #22 cable
10 50 Shut down #2 Rotary
12 00 Out #4 #55 and #22 cables
12 15 Shut down #4 Rotary
6 30 Started #2 Rotary shut #6 [illegible]

[illegible] 25020

FRIDAY NOV 15 1912

Day #2 Rotary running in 51 #52 cable
#55 cable [illegible] #2 cable on "C" hour
7 10 Started #2 Rotary
7 15 Cut out #5 #22 cable on "C" hour
7 20 Cut in #55 cable on "C" hour.
7 20 Cut out #51 #52 cable [illegible]
7 45 Started #6 Rotary
8 05 Cut in #1 #51 #52 cables
9 05 Started #1 Rotary
8 14 Cut out #2 cable.
10 00 Cut out #53 #54 #55 cables
10 35 Cut in #53 #54 #55 cables
10 40 Cut in #3 cable.
10 40 Cut out #5 cable.
10 55 Cut in #5 cable.
11 20 Cut out #22 cable
[illegible] Cut in #21 #23 cable + Cut out #23 [illegible]
[illegible] Cut in #22 cable.
[illegible] Cut in #23 cable + Cut out #21 #22
[illegible] Cut out #3 cable.
2 45 Started #1 Rotary down #3 Rotary.
3 05 Cut in #3 cable, 4 5 Cut in #21 #22 cable

Battery floating on system

FRIDAY NOV 15 1912

Battery floating on system.
Low tight working on #1 rotary.
Changed #40 + felt funning as Am.
Ground on underground desk ✓
Ground on test heads in station.

FRIDAY DEC 6 1912

Night. #1-2-3-4+6 Rotarys running on #51 53 + 55 bus
6[02] Shut down #1 Rotary
6[45] Shut down #4 Rotary
8[10] Started #4 Rotary down #6
11[30] Shut down #4 Rotary
11[52] Cut #55 cable off system + cut in #55 + 21 cables on A
12[00] Cut out #705 + 721 feeders
12[10] Shut down #3 Rotary
~~12[10] Shut down~~
12[20] Cut out #53 + 3-53 cables
[illegible] Cut in #53 + 3-53 cables
6[55] Started #3 Rotary
7[00] Cut in #705 + 721 feeders

KW 32 = 1/4

SATURDAY DEC 7 1912

Day [illegible] Rotarys, Summary on #5 -53+55- cable
[illegible] Started #1 Rotary
7[30] Cut out #55 + 21 cable off A Bus
7[45] Cut out #1 cable
7[55] Cut in #1 cable
9[35] Cut out #55 cable
10[00] Cut in #55 cable
10[20] Cut out #51 cable
10[40] Cut in #51 cable
10[40] Cut out #53 cable
11[15] Cut in #53 cable
10[15] Cut out #5 cable
10[22] Cut in #5 cable
10[30] Cut out #5 cable
10[35] Cut in #5 cable
11[20] Cut out #55 cable off system
11[20] Cut in #55 + 21 on A Bus
11[25] Cut out #55+21 cables off A Bus + cut #55 on
11[37] Cut out #55 cable from [illegible] + cut in #55+21 cables
11[49] Cut out #55+21 cable off A Bus + cut in #55 cable
11[20] Cut out #1 + #3 cables
10[--] Cut in #3 cable, 11[--] Cut in #1 cable
4[30] Started #4 Rotary
5[02] Cut in #21 + 2 cables on A Bus

K.W. 41097

See Diagram Book Switching P.H.

FRIDAY DEC 6 1912

Battery floating on system.

Made insulation test on #53 cable

SATURDAY DEC 7 - 1912

Battery floating on system.

730 Man from meter dept removed meter connections on #5 Watt Meter.

Mr. Smith of Underground dept. Experimented & refilled Pot heads of N. cables in station.

Conn dept working on oil switch for starting motor of #6 Rotary.

SATURDAY JAN 4 1913

SATURDAY JAN 4 1913

Battery floating on system.

SUNDAY JAN 5 1913

Battery floating on system.

SUNDAY JAN 5 1913

Battery floating on system.

MONDAY JAN 6 1913

Battery floating on system.

Mr. Hendrick of D.P.S. dept refilling cable pot heads at station one dept worker at battery house basement and testing cables as usual with Wheatstone bridge.

574

MONDAY JAN 6 1913

MONDAY JAN 6 1913

TUESDAY JAN 7 1913

694
147

MONDAY JAN 6 - 1913

Placed 1 unit in cable vault
#34 3x4 2-7 cables (C.F.)
Interference, placed 1 unit in
#1 Vault.

Placed 1 unit in operating gallery
between 4th & 5th units.

MONDAY JANE 1913

Battery - floating system.

TUESDAY JANT 1913

Battery floating system.
Commenced working in battery
room 1 unit.
Placed 1 unit resting cable
in cable vault.
Placed large floating ebonite rubber
pipe in switch house ventilator.

Tested Rectifiers at 11 P.M. Sh. #2
#2 #21-31-3 cables + #1 Station
Tested with [illegible] Shunts
#2, #3 (2) Shunts [illegible]

DEFENDANT'S EXHIBIT X 695

THE AUSTRALASIAN CABLE QUESTION.

A FEW months ago we (*Imperial Federation*) called attention to an official statement made in the House of Commons that telegraphic communication with the Australian Colonies had been dependent solely upon the line through Russia only once during the six years from 1881 to 1886. The deduction which every one was expected to draw from this was that interruptions were of the rarest occurrence, and that an alternative route was therefore unnecessary. Perhaps the following record of the cable interruptions on the Australian route between the years 1872 and 1888 (we are unable to furnish later figures) will show that it is living in a fool's paradise to believe that breakdowns are few and far between. Indeed, it is only the fact that the line is in duplicate that has saved the communication from being constantly defective. We are unable at present to lay our hands upon the dates when the two lines between Singapore and Port Darwin were laid down, but we shall endeavour to discover this for the benefit of the public, who ought not to be allowed to remain in doubt as to the exact measure of their security. It is, however, a subject of serious matter when we find that in the twelve years under review there have been no less than 50 breakdowns, totalling up to a period of about 500 days, or 18 months, during which one portion of the direct cable route to Australia was unavailable. We now give the list, leaving our readers to form their own opinion as to the entire trustworthiness of cable communication with Port Darwin, the only point to be remembered, in Australia who is connected with any other continent by cable.

CABLE INTERRUPTIONS ON THE AUSTRALIAN ROUTE, 1872–1888.

When Broken.	When Restored.	Where between.
1872 June 22	July 26	Port Darwin and Banjoewangie.
1873 Feb. 21.	Feb. 24	Land line between Buzki and Banjoewangie.
March 31.	April 2.	Batavia and Singapore.
May 12	May 26.	Penang and Madras.
July 13.	July 13.	Land line 30 miles from Banjoewangie.
Nov. 20.	Nov. 23.	Singapore and Penang.
1874 May 20	May 31.	Batavia and Singapore.
Aug. 13.	Aug. 15.	Ditto.
Aug. 16.	Aug. 23.	Ditto.
Dec. 10.	Dec. 29.	Ditto.

Floating station was established 16 miles from Batavia, with daily steam communication to Singapore, on December 18th.

1875	Sept. 2.	Sept. 16.	Batavia and Singapore.
	Nov. 5.	Nov. 8.	Ditto.
	Nov. 15.	Dec. 24.	Penang and Madras.
1876	March 28.	Aug. 24.	Ditto.
	April 24.	Aug. 7.	Port Darwin and Java.
	Oct. 22.	Nov. 30.	Batavia and Singapore.
1877	Feb. 26.	March 2.	Ditto.
	July 15.	July 17.	Singapore and Penang.
	Sept. 26.	Oct. 13.	Batavia and Singapore.
	Oct. 19.	Oct. 31.	Singapore and Penang.
	Nov. 8.	Dec. 15.	Port Darwin and Banjoewangie.
1878	Jan. 22.	Feb. 3.	Batavia and Singapore.
	March 11.	March 13.	Land line between Sitoebondo and Surabaya.
	Sept. 26.	Oct. 5.	Port Darwin and Banjoewangie.
1879	May 29.	May 30	Ditto.
	July 1.	July 24.	Ditto.
1884	March 5.	March 7.	Ditto.
	March 9.	March 16.	Ditto.
	April 6.	April 9.	Ditto.
	Oct. 22.	April 26.	Ditto.

Supposing that cable communication between Port Darwin and London were absolutely perfect, and secured against the faintest possibility of a breakdown, there would still be cause for the gravest anxiety should it be a matter of urgency to send telegraphic despatches to our great Australian Colonies.

It must be remembered that the whole continent of Australia has to be traversed by a single line before that network of telegraphs in the south is reached, where total interruption is a practical impossibility. The nearest telegraph station in Queensland is several hundred miles from the trans-Continental line over which every message from Europe to Adelaide, Melbourne, Sydney, Brisbane, and New Zealand has to pass.

It is sometimes supposed that a land wire is perfectly safe. So far as the Queen's enemies are concerned this is true, but there are natural forces which give more trouble than hostile grappling-irons. Between Port Darwin in the north, and Port Augusta, where the branches diverge from the trunk line in the south, there have been in the 12 years, from 1872 to 1884 inclusive, 50 separate occasions on which communication has been interrupted, covering a period of 201 days.

What, then, is the use of relying upon duplicate cables and security of communication by sea, so long as these interruptions take place on the land? Some of the stations are very long distances apart, and priceless time might elapse in answering some urgent message across the hiatus caused by a break down. Is it not the height of ridiculous folly to lean upon the fancied safeguard of this transcontinental wire, which has so often failed us? It is admitted on all hands, that *immediate* notice of a declaration of war would be a necessity if the shipping in Australian waters is to be confined to port, and the harbours are to be protected against attack. And yet the only means of sending prompt information to a single port in Australia or New Zealand hang upon the immunity from damage of a single line of telegraph, which can only show for a testimonial the record of 50 interruptions in 12 years. The list is too long for us to publish the whole of it; but we append a summary, which shows that the break downs can be reckoned upon to occur in every year, to a greater or less extent.

INTERRUPTIONS ON THE TELEGRAPHIC LINE BETWEEN PORT DARWIN AND PORT AUGUSTA.

Year.	Number of Times Broken.	Total Period of Interruptions.	Year.	Number of Times Broken.	Total Period of Interruptions.
1872	2	6 days.	1878	19	38½ days.
1873	7	18 days.	1879	13	22½ days.
1874	8	20 days.	1880	2	2 days.
1875	8	17½ days.	1881	3	5½ days.
1876	9	25 days.	1882	5	6½ days.
1877	17	34 days.	1883	5	6 days.

We hardly know where to look for comfort whether the cables or the land-line are about to be trusted. But surely the case is strong enough to be taken in hand without delay. Many millions sterling are hazarded on this question of rapid and secure communication with Australia. Merchants in London are concerned in it, no less than in the Colonies; and if the Imperial Conference is allowed to meet and disperse without a definite course being adopted to remedy the dangers of the situation, a very grave responsibility will be attached to every member of it, who having the opportunity, has failed to lift up his voice in earnest protest against the neglect of so vital a matter.

THE ECONOMY AND EFFICIENCY OF UNDERGROUND ELECTRICAL CONDUCTORS IN CITIES.

By DAVID BROOKS.

WHEN Mr. W. H. Preece, the chief electrician of the English Post Office Department, was in this country two years since, he stated that whenever the Government could get as many as 15 electrical conductors into one route or channel, they found it both advantageous and economical to place them underground. Mr. Preece's experience with underground electrical conductors, as compared with overhead conductors, was almost entirely with the underground conductors insulated with gutta-percha.

The cost of a No. 18 British gauge wire, insulated with gutta-percha, according to the Government standard, is about £75 per mile. These conductors are drawn into cast-iron pipes, usually buried beneath the sidewalks at an average depth of two feet below the surface. This is the cost of the conductors themselves: but the expense of the trenching, the iron pipes, the drawing-in and splicing, brings the cost of these wires when laid to £100 or over per mile. Gutta-percha insulation is expensive.

By the use of oil, and a textile covering for the wire, instead of the gutta-percha insulation, we can lay three times as many of those conductors in this country for the same amount of money. In Europe we can lay at least five times as many conductors of the same gauge for the same expense.

Durability.

The next question for consideration is the comparative durability of the different systems. Gutta-percha or India-rubber, like all vegetable or organic matter, undergoes disintegration and decay, but much depends upon the condition in which it is used. As it is used in England, it lasts from seven to ten years. It is exposed to the influence of damp and impure air. The French use the same kind of insulation, but they draw from five to seven conductors into a lead pipe, which is afterwards pressed tightly around the group of conductors, so as to exclude the air: and by that means they have made the insulation last 30 years: so I was informed in 1881 by the French electrical engineers;

Dimms lead. p. 203.

576

and for all I know those conductors are working yet. Within the last few years they have laid a large amount of those lead-covered cables, drawn into cast-iron pipes of larger diameter, and have wires working now underground from Paris to Marseilles and other cities of the Republic. Gutta-percha, when buried in the sea, and away from the influence of the air and the light, is said to be practically imperishable; but when suspended in the Paris sewers, and unprotected by the lead covering, it lasts but a short time.

The life of an insulator is dependent upon its durability. As a gutta-percha insulating material goes into decay, it does not become a conductor of itself, but it cracks and then admits moisture, and the moisture in the cracks becomes a conductor. Conductors insulated with India-rubber made from old shoes has every appearance of presenting as high an insulation as those insulated with fresh Para rubber; but the life of the former is comparatively short as an insulator, because the material itself has lost its vitality.

There are different methods of preserving materials of all descriptions, but as a general thing almost any organic matter and the metals can be preserved if we protect them from the effects of light, heat, moisture, and the air. As a rule, heat is not a factor in the decay of electrical insulating materials, for, as commonly used, they are not subjected to the influence of abnormally high temperatures.

I insulate underground wires with oil and a textile covering. All traces of moisture, air and light are excluded. There is nothing that can in any way affect the contents of the pipe. The textile covering is preserved by a hydro-carbon, the most stable of all materials, the same that has preserved the linen covering of the Egyptian mummies for thousands of years. The hydro-carbon preserves the inner surface of the pipe, the copper conductors and their covering. No change can take place in the condition of those materials, and, as a consequence, no change can take place in their insulating properties, as the insulation is entirely dependent upon the durability of the insulating materials; or, in other words, the durability is more a question in physics than an electrical question. If I were asked how long a glass insulator would last, I would say just as long as the glass remains whole and entire. I am often asked if the electrical current does not affect the oil. I say, no more than it affects the glass insulator on the poles. Such non-conductors as glass or oil, or any other equally good insulators, are unaffected by a current of electricity.

This much relates to the inner surface of the pipe and its contents. The outer surface of the iron pipe is protected from rust by being enclosed in a wooden box of sufficient dimensions to contain the iron pipe and a concrete covering composed of pitch and sand, which effectually prevents oxidation of the outside surface of the iron pipe. Under these conditions the system can be said to be indestructible except by mechanical means. So much for durability.

The Ease and Facility with which the System is Laid.

As much as 2,000 feet of trench have been dug, and the lengths of iron pipe screwed together, and the trench filled and repaved in one day. The inside of the pipe having been scoured and polished perfectly smooth, 2,000 feet of cable can easily be drawn in. The oil acts as a lubricator, enabling the cable to slip along easily and without friction. Nor is it necessary that the pipe be laid in a straight line. We go either above or below gas or water pipes, or to one side or the other of any obstruction we meet.

Three 3-inch diameter pipes, with carrying capacity of 1,530 conductors are laid in Calhoun Place, Chicago. The wooden box containing these pipes has less than one square foot of section. A mile of cable could be drawn in, in one length, if it were desirable.

By having a short piece of the pipe bent so as to form a 90° segment of a circle, the radius of the circle being two feet, street corners can be turned with ease, and cables have been drawn around two of such corners without producing a sensible or material increase of friction. By the use of the splice boxes, or hand holes, as many as 500 splices have been made by one person in a day. In New York, hand holes were inserted every 15 feet, making it easy to bring out conductors and lead them into adjacent buildings; and they are so introduced, every portion of the wire from the building to the exchange being underground. Of those 800 conductors now in use for two years, not one has failed or cost one penny for maintenance or repairs. Another method is to bring out under the sidewalk, through the cellar to the rear of the building, as many conductors as will be needed in that block. They can be distributed from a short pole easily to any or every building in that block. A property owner would sooner grant this privilege than have poles standing in front of his building, as such poles must necessarily be high, and the snarl of wires radiating from that structure presents a very unsightly appearance.

For Telephonic Lines.

The system is peculiarly adapted for telephonic purposes, being free from inductive disturbances and overhearing or eavesdropping. Those having interests in telephonic exchanges should consider the advisability of applying a portion of their earnings to the placing of the conductors underground. They should take into consideration the expense they are now under of having so large a force employed to hunt up and remove "trouble," and the vexatious annoyances occasioned by the frequent interruptions of the overhead service. The outlay incurred in maintaining the force simply to remove "trouble" would pay an interest on a very large amount of capital. They should take into consideration that these overhead conductors are getting weak and brittle from exposure to the atmosphere of cities. The main telephone patent will expire in a little over six years. During this time, with judicious management their conductors can be buried, and the expense of this work paid out of the earnings of the company. A stockholder would part with his stock while it is paying 12 per cent. at a less price than he would were it paying 6 per cent., if he knew that when the time arrives for the patent to expire the conductors would be underground, and the expenses of putting them were paid. Would a competing company easily raise the funds to put down a plant to compete against a company whose plant is already down and paid for? It is evident that the present companies would be as well protected under these circumstances from competition as they are now by the patent itself.

It is also well to bear in mind that since electric lighting came into use many of the telephonic exchanges and telegraph offices have been either destroyed or seriously damaged by fires occasioned by electric light conductors coming in contact with the telephone or telegraph conductors, and this danger will continue so long as these different electric conductors remain overhead. In New York, Brooklyn, Philadelphia, and other places, people have been killed by coming in contact with electric light conductors. Chicago is the only large city that has not suffered in this respect, and the reason is that all the electric light conductors are underground. Chicago is in advance of all other American cities in this underground business. Chicago has one-third more telephone subscribers than Philadelphia. The Bell Telephone Company, of Philadelphia, employ twenty more men than the Chicago Telephone Company to remove interruptions to their circuits. The Philadelphia Company have no wires underground.

For Telegraphic Lines.

For telegraphic purposes few are aware of the advantages of having the wires placed underground in cities. The glass insulators in cities soon become coated with soot or carbon, and thousands of insulators are in use that will not show an insulating resistance of one megohm. There is as much loss of current over one insulator so situated in rain and dampness, as there is in 20 miles of the line in the country, where the insulators

are clean and affected by moisture only, which is comparatively free from impurities. When lines are worked upon the same set of poles with positive and negative currents, the interference from wire to wire by these batteries short-circuiting into each other, commonly called cross-currents, is so great that some of the circuits have to be opened in order to enable the others to be worked. The telegraph officials in Chicago all speak of the great advantage derived in this respect from having their wires placed underground in that city.

For Electric Lighting Wires.

For electric lighting this system is peculiarly well adapted, both for arc and incandescent. By the use of these splice-boxes and hand-holes the conductors can be brought into the buildings for house-to-house purposes, or into the ordinary street lamp-posts. The conductors for such purposes can be drawn in singly or a number of them in a group, as circumstances may require. Oil is the strongest insulation known, or least liable to be affected by currents of high potential and quantity combined.

Underground Conduits.

Underground conduits first began to be invented in England about the year 1850, and from that time until 1860 many patents were taken out for different forms and materials. But a great many patents have been taken out in this country within the past ten years for that class of inventions. Neither in England nor in this country have the patentees been known as having much or any electrical experience. These various patented conduits are supposed to facilitate repairs by easy drawing in and out. From the nature of the case, conductors placed in these receptacles are continually in need of repairs. The atmosphere of the conduit is full of gases that will soon affect and destroy anything that is put in them. Some of the gases are heavier than the air, and their tendency is to collect and stay in the conduit. They act upon the metals, lead and iron like stagnant water, and no insulating covering of any kind can long withstand the effect. They are always damp, and the inner surface so wet that nothing is gained by having the material of the conduit itself made of a non-conducting substance.

It has been proposed to make these conduits of wood, but such a structure decays very rapidly, as was shown in the early experiments in England. A piece of wood buried in the ground, with the earth packed closely around it on all sides, lasts ten times as long as a wooden box containing damp and impure air. The decay begins on the inner surface of the box, that portion of the box coming in contact with the impure air, and no means have ever been devised to prevent it.

The writer has spent the last four months in Chicago and has had abundant opportunity to examine the different systems there. That of the Dorsett has fewer conductors and in much shorter lengths than I laid for the Metropolitan Telephone Company, in New York, two years ago, which has not cost one cent for repairs nor have any of them failed or deteriorated. But in Chicago, although the conductors have been in the ground a shorter length of time than have those I laid in New York, three men are continually employed, in Chicago, in repairing and removing faults or interruptions. The lead covering is often eaten through by rust.

They dare not go near the manholes with a fire or soldering pot for fear of explosions. I had myself an experience. The Chicago Telephone Company had arranged a manhole for bringing in the wires, opposite No. 91, Jackson Street. When we sent a man into the manhole with a lantern, to splice the wires, an explosion took place, which set fire to the covering of the wires. In order to put out this fire, snow was shoveled on and by that process they got water into the pipe, which delayed our work two days.

A galvanised wire drawn into one of these conduits six months since, when pulled out showed no traces of zinc covering, it having been so affected by the atmosphere of the conduit.

Another objection to these conduits is their cost. I can lay alongside the conduit put down on Sixth Avenue, New York, an equal number of conductors that can be got into that conduit, the conductors being of equal insulation and conductivity, for less money than the conduit costs, without wires in it. And I will guarantee the interruptions or failures from every cause to be less in the conductors I lay than those in the conduit, in the proportion of one to 100."

Lead-covered Cables.

A lead pipe of sufficient diameter to contain 100 conductors, costs as much per foot as an iron pipe containing 300 conductors. If as many as 200 conductors can be got into one route, it costs no more to place those conductors underground in an iron pipe than to string them overground in lead pipes, and in the latter position they are liable to injury from fire, as almost every telephone exchange using lead-covered cables can testify. If lead-covered cables are placed underground they have to be imbedded in asphalt or pitch, to protect the lead covering, and in case of an accident happening to the conductors it is extremely difficult to find and remedy the trouble.

The lead covering is seriously affected, as before stated, by the atmosphere of the conduit, and lead-covered cables are extremely unwieldy to draw out of a conduit.

In our system, the cables can be easily drawn out of the iron pipes if occasion demands it. We have only had one such occasion and that was in Chicago, when it became desirable to substitute a 250-wire cable for one which had only 150 conductors in it.

The London *Electrician*, of May, 1886, contains the following experiments with oil as an insulator, by H. C. Frempt :—

"The oil used to insulate the underground wires running into the telephone exchange, at the corner of Broadway and Spring Street, New York, is heavier than water. Take two cotton-covered wires which have been boiled in that oil, draw them through glass tubes, twist the ends together, and place them in an ordinary glass battery jar. Fill the jar half full of oil, after which water may be carefully poured into the jar and it will remain above the oil. Attaching the poles of a battery to each of these wires, as shown above the glass tubes, no current will be observed as passing from one wire to the other.

"Take a piece of lead pipe containing a cable of cotton-covered wires insulated with the same oil in a fluid condition, and cut a hole in the lead an eighth of an inch in diameter. The oil being viscous will ooze out slowly. Place the cable in a jar, and fill the jar with water, the oil will continue to flow till an equilibrium is established, but no current can be passed from one wire to the other or from either wire to the lead pipe. Now, if instead of oil we use in this experiment paraffin, pitch or resin, the insulation immediately fails.

"Six years ago since there was a lead-covered cable insulated with oil, armoured and laid across the Delaware River. The cable contained 50 conductors, not one of which has failed. The cost of this cable of 50 conductors was no more than that of an ordinary gutta-percha insulated cable of five conductors. The gutta-percha insulated cables across the Delaware during this period has been continually subject to mishaps. Many of the conductors have been injured by lightning, although protected by lightning arresters. When the gutta-percha insulation is punctured by atmospheric electricity, it leaves a hole in the insulation in which water enters, by which the current passes to earth. The cable has to be under-run, the leak found and the hole sealed up, but a hole cannot be made in a liquid."

The splice boxes we use will hold two gallons of oil after the splices are covered with oil. When the splices are covered by the oil we can fill the remaining portion of the box with water without affecting the insulation of the conductors.

Philadelphia, *February 15th*, 1887.

DEFENDANT'S EXHIBIT Y

NO. XVII

HANDBOOK
of
PRICE LISTS, TELEGRAPH CODE AND USEFUL INFORMATION

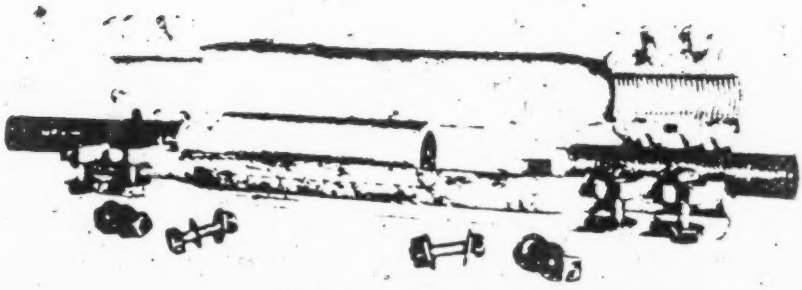
RELATING TO
BARE and INSULATED WIRES
and CABLES
for the CONDUCTION of
ELECTRIC CURRENTS

BY
JOSEPH W. MARSH

COPYRIGHT
1906
BY THE
STANDARD
UNDERGROUND CABLE CO.
PITTSBURGH, PA.

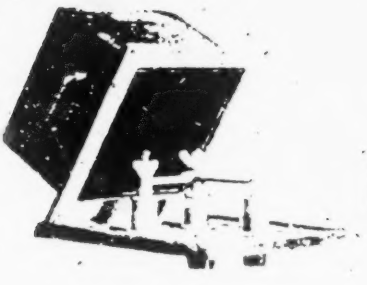
A

B



C

D



E

A— B—
D— nipple E—

BRASS AND COPPER TERMINALS

For Terminating Electric Light and Power Cables

(For description see p. 128. For illustration see p. 42-a)

Diam. of Cable, Inches	Voltage	Kind of Bell	Approx. Diam. Top of Bell	Price	Telegraph Code
up to 1 3/8	up to 6,000	Cast Brass	4	$ 6.00	genus
1 1/2 to 1 7/8			5	8.00	geometry
2 to 2 1/2			5 1/2	10.00	geranium
1 3/4 to 2 3/4	6,000 to 12,000 Volts	Spun Copper	9 1/16	20.00	ghostly

These prices include hard rubber caps for all bells and, in the case of the spun copper bells, additional mica tubes 10 inches long for reinforcing the insulation at the cap.

ONE-PIECE MALLEABLE IRON CABLE HANGERS

(For description see p. 129. For illustration see p. 154-b)

Stock No.	Width of Opening, Inches	Diam. of Cable to which Applied, Inches	Price per 100	Telegraph Code
1	5/8	1/2	$3.00	gift
2	3/4	5/8	3.00	giggle
3	7/8	3/4	3.00	gilded
4	1	7/8	3.25	gillie
5	**1 1/8**	**1**	**3.50**	**ginger**
6	1 3/16	1 1/16	3.75	gipsy
7	1 1/4	1 1/8	4.00	giraffe
8	1 3/8	1 1/4	4.25	girding
9	1 1/2	1 3/8	4.50	girlhood
10	**1 5/8**	**1 1/2**	**5.00**	**girth**
11	1 3/4	1 5/8	5.50	glacier
12	1 7/8	1 3/4	6.00	gladiator
13	2	1 7/8	6.50	glassy
14	2 1/8	2	7.00	gleeful

NORDYKE CABLE SUPPORT FOR MANHOLES

(For description see p. 130. For illustration see p. 148-a)

For Use as	Price, Each	Telegraph Code
Wall Bracket	$0.20	glen
Extension Bracket	.20	glibly

OZITE OR WARING INSULATING COMPOUND

For Filling Joints, Terminals, Junction Boxes, Transformers, etc.

(For description see p. 131. For illustration see p. 42-b)

Size of Packages	*Ozite Insulating Compound		Standard Terminal Compound	
	Price per Gallon	Telegraph Code (See p. 52)	Price per Gallon	Telegraph Code
1/2 Gal. Cans	$1 65	gloaming	$2 15	glover
1 " "	1 50	globule	2 00	glowworm
2 " "	1 40	glomerous	1 90	glucinic
5 " "	1 35	glorify	1 85	glucose
50 " Barrels	1 30	glossary	1 80	gnarled

*No. 1 Ozite is hard, No. 2 is medium soft and No. 3 is soft, at approximately 60° Fah. In ordering state the purpose for which the material is desired and the conditions as to temperature.

cent lamps cannot cause explosions, first, because the filament is hermetically sealed in the glass bulb; and second, because the moment the glass is broken, the filament is destroyed. Steam or compressed air for operating pumping, hoisting and drilling apparatus in mines will vitiate the air and rot the timbers, while candles or lamps consume the oxygen in the air; thus rapidly undermining the health of the workmen. The vast improvement and economy from a financial and hygienic point of view, made possible by the introduction of the Electric Light and Motor in mines, merit the closest study of mine owners and operators. The importance of uninterrupted transmission of signals, light and power is so great, that the question of the excess in the cost of lead covered electric cables over that of bare or insulated wire is not worthy of consideration. Lead covered cables are absolutely safe for conveying the electric current for either of the purposes here named; they are flexible and can be laid to any portion of the mine.

The Standard Underground Cable Company has spared no effort or money to produce a cable that will meet every condition that obtains in practical work, and to this end it has for many years past had in its employ the best mechanical and electrical experts that could be procured. It is largely due to this policy that the Company today stands in the forefront of progess in the manufacture of Underground Cables.

Our LEAD COVERED CABLES are in daily use all over the United States and for every conceivable electrical service, many of them having been in successful operation for a period of twenty years; no other company has had the varied, extensive, and withal successful experience that we can point to. When you buy our cable you buy an article that has proven itself worthy of public confidence, and from a company that has a reputation at stake, which it would not impair by careless or imperfect workmanship, and that is financially responsible and able to carry out any obligations that it takes upon itself.

Our experimental and testing laboratories are equipped with the most modern appliances for research work as well as for the daily testing of our products; they are in charge of the most competent and experienced cable engineers in this country,—some of them of international reputation; and our manufacturing and construction departments are in charge of engineers and experts who have had many years of successful practical experience in their several departments.

We are therefore prepared to give the best technical and practical engineering advice as to cables, their insulation and installation, to meet the conditions for which a purchaser may desire to provide. And since we manufacture cables with all styles of insulation, and in any form at present in use, we are in a position to give unprejudiced expert advice on this subject, and shall always be pleased to respond to our customers' inquiries.

The **most important features** in underground cables are,
FIRST, The insulation; and
SECOND, The protective covering to safeguard that insulation against injury from chemical, mechanical or atmospheric actions.

These features will now be considered in detail.

INSULATION

This may consist of
(*a*) Fiber (cotton or jute yarn or woven fabrics);
(*b*) Paper, applied in the form of tape; or
(*c*) Rubber Compound.

Our factories are amply equipped to furnish any of these forms of insulation, according to our customers' wishes and the requirements of the case.

If the insulating body is fiber or paper, it is necessary (except in the case of dry core telephone cables) to saturate it with an insulating compound, and the character of the compound is of the utmost importance in determining the quality and permanence of the cable.

The success achieved by us in the manufacture of underground cables was due to the invention and constant use of

our insulating compound known as **"Ozite"** or **"Waring Insulation"** (see page 137) as the saturating and filling medium in fiber and paper insulated cables. It is a hydro-carbon, inorganic compound, and not subject to deterioration from age and use, and it combines a very low specific inductive capacity with high insulating properties. (See Comparative Table, on page 186.) When fibrous insulating media (such as paper, cotton, jute yarn, etc.) is saturated with it, an insulating material is formed which is much better able to withstand high temperature than is gutta percha or rubber. All experienced cable users will at once appreciate the prime importance of these superior qualities.

By exhaustive experiment and long practical experience we have determined the proper modifications of our insulating compound to meet varying conditions of installation and service. If the cable is to be installed in very hot weather, or used under conditions subjecting it to constant high temperatures, the compound is made comparatively hard; if on the other hand, the cable is to be installed in cold weather or used at moderate or low temperatures, the compound is made soft. In this way, we minimize the loss of insulating compound at the ends of the cable when the jointing is done at high temperatures, and minimize the danger of cracks in the insulating wall due to handling the cable in cold weather.

The measured insulation resistance for a given compound and a given size of conductor and thickness of insulating cover, will be found quite uniform, but naturally it varies for the different modifications of the compound from hard to soft, and with the thickness of insulation and the size of conductor. An interesting table of variations according to size of conductor, will be found on page 180. Do not make the mistake of concluding that a high measured insulation means ability to withstand high pressures, for the opposite is, broadly speaking, the case; we have so thoroughly demonstrated the latter statement, by both theory and practice, that it is taken as a matter of course by experienced engineers. In a saturated cable, a high measured insulation means a hard compound which, upon subjecting the cable to the unavoidable bends in installing it, will cause the fiber or paper to crack and so provide an easy path for the high pressure current to burn out the cable; on the contrary, a very soft compound, although it will show a far lower measured insulation (even five or ten megohms is sufficient, if uniform) will permit the necessary bending of the cable without danger of breaking the fiber or paper, and so effectually seals all pores and interstices as to afford the ideal conditions for maximum resistance to breaking-down strains. For these reasons it is the practice of the leading engineers to specify relatively low measured insulation resistance for all electric light and power cables, even though they may be intended for pressures of 11,000 to 25,000 volts.

FIBER INSULATION

In making cables of this class the wires are thoroughly and evenly covered to the desired thickness, by windings of jute or cotton yarn, (see page 38-a) or by tapes of cambric or linen cloth (see page 28-b); all moisture is expelled from the covering by baking the core thus prepared in suitable ovens whose temperature is carefully regulated and the cable is then thoroughly saturated and all interstices filled by immersion in tanks containing our melted compound kept at the proper degree of heat; the core is then ready for the lead cover.

If the insulation consists of tapes of cambric or linen, these tapes may be first baked, and saturated and coated with the proper insulating compound or varnish, and then wound upon the conductor to the desired thickness and passed on to the lead press with or without further treatment in the compound tank or covering machines.

A cable of this class, like cables with paper insulation, is not strictly waterproof without the addition of the lead cover. Special means must be adopted to protect the ends of such cables against moisture, but this is accomplished in a manner so easy and rational, (as explained under "Terminals" on page 126) that it constitutes no drawback whatever.

These fiber insulated cables (and the same is true of saturated paper insulated cables) when subjected to moisture by an

52d CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { EX. DOC. No. 15.

ELECTRICAL COMMISSION OF THE DISTRICT OF COLUMBIA.

REPORT

OF THE

ELECTRICAL COMMISSION

APPOINTED

TO CONSIDER THE LOCATION, ARRANGEMENT, AND OPERATION OF ELECTRIC WIRES IN THE DISTRICT OF COLUMBIA.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1892.

Description of Conduits.

AMERICAN CONDUITS

The various American conduits now in use are, with few exceptions, fully described under the head of New York, Chicago, and Philadelphia subways. There are countless other devices developed almost daily, but want of sufficient trial does not warrant more than a mere mention of some of them.

THE LYNCH LAKE SYSTEM.

In Baltimore, Washington, and recently in Chicago and other cities, rectangular glazed terra-cotta conduits, under the Lynch-Lake patents, have been extensively introduced with strong indications of success in every respect. The illustrations of their detail construction accompanying this report are sufficiently clear to require but little explanation. The clay ducts are made with two, four, and six chambers, more usually, two and four, owing to their convenience in handling. The sections are 3 feet long with partitions slightly leveled at their outer edges. The joints are effected by the use of a sleeve set in cement mortar.

The best practice, in our opinion, though most costly, is in laying of these conduits upon a substantial bed (usually 6 inches thick) of concrete and surrounding each separate horizontal series of ducts with a 3-inch layer of mortar or gravel concrete, thus insuring not only a compact rigid mass but also protection against mechanical injury, external moisture, and entry of gas. With careful and substantial construction of the manholes and the inclosure of manhole masonry with an inch layer of cement, mortar or concrete and a reasonable provision for ventilation, the occasional explosions in conduits which have been experienced in American cities will be obviated.

CREOSOTED WOOD.

The creosoted wooden duct conduit, under what is known as the McDonald patent, has been adopted and exclusively used by the Philadelphia authorities. It consists of machine-bored creosoted planks 16 feet in length, arranged and put together in connection with manholes, as illustrated in plates 9 to 14. It is an excellent system, and has now withstood the test of five years with very few accidents or necessary repairs. The wood is all treated with the dead oil of coal tar, and is said to show no signs of deterioration thus far.

The Brooklyn creosoted wooden duct system varies only in detail of construction from the Philadelphia plans, and is not patented. In other respects it is substantially the same and is favorably reported upon.

INDURATED FIBER.

A conduit which it is understood has already been laid in several cities to a considerable extent is the patent hard fiber (indurated fiber) pipe, made of compressed wood pulp chemically treated, manufactured exclusively at Mechanicsville, N. Y., under the Medbery patents. Its inside diameter usually ranges from 1 to 4 inches. Reports concerning the quantity of this pipe laid and contracted for in Buffalo, N. Y., show 500,000 feet for the feeder wires of the electric system of the Buffalo Street Railway Company, constructed by the Field Engineering Company, who are said to recommend this pipe highly. The reported quantity laid in Detroit, Mich., for electric-light wires is 200,000 feet, with over 50,000 feet in Philadelphia for telephone cables. The pipe is also re-

[illegible] for electric-light wires in New York City, Augusta, Ga., Fort [illegible], and Chicago, and Milwaukee for signal wires along the lines of the New York Central and Hudson River Railroad Company, the Pennsylvania Railroad, and the Delaware and Hudson Canal Company.

INTERIOR CONDUIT SYSTEM.

The interior conduit system is an adaptation of plans of interior house work to an outer conduit system. It has been applied in several American cities for conducting high-potential currents upon bare wires placed within the tubing of this system. Its advocates claim economy in the saving of lead casing and insulating material of conductors. The space required for each duct, and the fact that only one wire can be placed in each duct, confines its use to large single wires traversing long distances for power and lighting purposes.

THE BROOKS OIL INSULATION SYSTEM.

This system, the invention of Mr. Davis Brooks, of Philadelphia, embodies the use of heavy mineral oil, one of the best insulators, as the dielectric for high-tension underground mains. The system has recently been brought prominently to the front in this country by Messrs. Johnson & Phillips, the representative of Mr. Brooks in this matter on our side of the Atlantic. The system has, however, been well known for many years, and has received much favorable commendation in this country from no less an authority than Mr. Preece, and in America numerous experts have testified to its efficiency, and dating back as far as 1877, in which year Mr. Brooks laid some experimental wires in Philadelphia.

In 1887 a line of 1¼ miles was laid by Mr. Brooks on the Pennsylvania Railroad. In this cable there were eighteen splices and fifty-three conductors, and a very high insulation value was obtained, and an important feature in reference to telegraph and telephonic circuits was practically demonstrated, viz, its low inductive capacity, which in this case gave a mean value of about 0.212 microfarads per mile.

The experience of America of over ten years, though almost exclusively telegraphic, amply demonstrated the permanence and efficiency of the system. Mr. Brooks claims in reference to these circuits that while other multiple cables have frequently broken down and developed faults due possibly to lighting and other causes, his circuits have never given way and continue to this day to give values as high as when the lines were first put down.

In the earlier experiments Mr. Brooks employed ordinary fluid mineral oil as insulating medium. This, however, was found to have a very high penetrating power, and continual care was needed to keep the oil confined. The oil now adopted, produced from the waste products of resin oil, is a thick, sticky mass, less liquid than treacle, and has the advantage of being extremely cheap.

Practical details have now been carefully worked out, and it may be confidently stated that the Brooks system, well carried out, has the best claims of permanency and efficiency of any underground high-tension system, and that it will probably contrast favorably as to cost with any other system of anything like similar insulation and permanency.

The dielectric is a pure homogeneous thick fluid of extremely high insulation value. It does not oxidize when exposed to the air, and when occupying the whole of the space in an iron pipe beyond that occupied by the conductors and their fibrous covering possesses all the elements of permanency—in fact theoretically, the system seems to exclude all the ordinary factors of decay, and the permanence of the system seems only limited by the life of the containing pipes, which in ordinary cases we believe have been known to last over twenty years when used for gas or water, where it must be remembered both the inside as well as the outside of the pipe is exposed to influences tending to cause decay: whereas in the Brooks system it is evident that no decay of the pipes could go on from the inside, and any deterioration that took place would be limited to the oxidizing and perishing process from the outside only. Hence it is urged with much show of reason that the Brooks system must rank well not on the score of insulation alone but on that of permanency.

The mechanical details of the Brooks system are seen in the accompanying plates.

The iron pipes are used in the usual lengths, made and kept in stock, and have their ends carefully bell-mouthed and connected together with T sockets, as shown in the small cut, Fig. 1; and at suitable distances draw-in boxes, Fig. 2,

are provided, which may or may not have glands for the cables to pass through, according to circumstances. Branch circuits are taken off by means of junction boxes fitted at points determined upon. The junction boxes are in all cases provided with glands for the cables to pass through, so that the fluid dielectric may be removed from the junction box for the purpose of making a branch connection, or for testing purposes, the glands then preventing the dielectric from flowing into the box from the pipes containing the mains.

The branch connections thereto are preferably lead-covered cables of the ordinary type, which also pass through glands. The junction boxes may also contain fuses between the branch circuits and the mains. The terminals are formed of cast iron of special form, provided with glands with suitable vulcanite sleeves, through which the ends of the cables are brought, Fig. 3. At the highest point at the line a tank or cast-iron box with removable lid is provided, which is occasionally examined and kept charged with the fluid dielectric, so as to insure the whole system being fully charged. A small trench being dug and a section of the line having been prepared and all joints in the pipes carefully made, the cables, which consist of ordinary stranded copper conductors, covered to a suitable thickness with raw jute or hemp strand, preferably by braiding, and again wound over all with a sewing of braiding, are coiled on drums and placed in a tank of the fluid dielectric and carefully heated up to about 300° F., and maintained at this temperature sufficiently long to drive off all moisture. The cable may be of suitable size and composed of varying number of strands. That shown in section, Fig. 4, consists of four cables of No. 13, with four pilot wires of No. 12 gauge. The end or ends are attached to a hauling-in strand of wire or rope previously passed into the pipes, and the cable is drawn in direct from the hot dielectric, Figs. 5 and 6, by means of a winch.

Messrs. Johnson and Phillips have made several very severe tests of the system at their works, and continue to have the strongest convictions that it is a reliable and efficient one. A line of 700 feet in length was laid down at Charlton, under the supervision of Mr. David Brooks, who visited this country in order to convey to Messrs. Johnson and Phillips his past experience in the carrying out of his method. The cable consisted of seven No. 18 wires, each wire double, cotton-covered, and braided with cotton twisted into a cable and braided over all. This length of cable was drawn into a 1-inch iron pipe, and the whole system filled with hot fluid dielectric. The line has now been down for about two years, and it is to-day as perfect as when first completed. During the interval many searching tests of the line have been made, and on many occasions six of the wires have been grouped into two circuits of three wires each, and a Kapp alternator giving 2,000 volts has been connected to one end of the line, and a group of incandescent lamps lighted at the other end for several hours continuously. Measurements made before and after the run showed no fall in the insulation, and it must be remembered that in this case a pressure of 2,000 volts was exerted between wires whose covering of cotton did not exceed one-sixteenth of an inch intimately twisted together.

Another line was afterwards put down at Charlton, one-tenth of a mile in length, containing two cables, each of 7-14 wires, braided with a fiber to a diameter of about five-eighths of an inch. These were drawn into the pipe in two lengths, and the whole system filled with dielectric. This line has frequently had, under the direction of Mr. Kapp, a pressure of 14,000 volts for five hours at a time upon it. The test was made by transforming up from a 2,000-volt Kapp alternator to 14,000 volts, and at the other end transforming down again to 2,000 volts, and then lighting twenty 100-volt incandescent lamps in series to full brightness. This potential gave a sparking distance between points thirteen-sixteenths of an inch at the dynamo end of the line, and at the far end of somewhat greater distance. The line tested immediately before and after the run showed no change in the insulation value.

A recent communication from America dealing with this system gives particulars of underground mains with liquid insulation laid for the Heisler Electric Company, which gives entire satisfaction, having been in constant use for nearly a year in circuits using very high E. M. F., varying from 2,400 up to 4,000 volts, and the remarkable feature is the fact that the insulation resistance is higher to-day than when first installed. Repeated efforts have been made to break down the insulation by subjecting it to various and unusual strains, such as suddenly breaking the circuit when the dynamo was running at its greatest speed, and also subjecting lengths of the line to a static charge equal to 140,000 volts. They stood perfectly, though this test is sufficient to break through every other kind of insulation, however perfect it may appear by galvanometrical tests.

In England the Brooks system has been used for a short length in the Keswick central station system. Two single No. 14 copper wires, twice braided with jute and inclosed in an iron pipe with liquid, are used for connecting the church with the overhead high-tension wires. The Brooks main goes under the grave-yard to obviate the use of overhead mains. The wires have carried the full pressure of 2,000 volts for a period of over fourteen months.

They have also been used on low-tension work in a large private installation for Lord Windsor, where 500 yards of four strands of 37 13, are worked two each in parallel as main conductors under the grounds from the dynamo room to the house, to entirely do away with the necessity of overhead wires. Various other private installations have adopted the system. Besides this the system has been for many years in use on certain railways in England for telegraph wires with very marked success.

Abroad Messrs. Johnson and Phillips have just furnished the Hongkong Electric Light Company with 2,000 feet of the Brooks main for high-tension work in connection with the arc lights for public lighting. These mains are to go under the streets to work with a pressure of 2,000 volts. The plant is now in process of erection.

Our illustrations give the details at quarter full size of the junction box and terminal box shown in prospective last week. The cuts are reproduced from the working drawings and practically explain themselves. Fig. 7 shows details of the junction box which is laid under the street level. The exits or glands for the cable are arranged so that they can be packed and can also be plugged inside to prevent oil escaping if the box is required to be left at any part of the progress of the work. In laying, the cables are drawn through from point to point at these boxes, into which the liquid insulation is afterwards poured and the lid securely fastened down.

Fig. 8 shows the terminal box, which stands directly under the switchboard at the generating or at the receiving end of the lines. Glands are provided when required in the case shown for two cables and pilot wires.

In this system it is seen that there is no space left for the accumulation of explosive gasses, or gasses injurious to the dielectric, as might be the case where a solid dielectric is used in conduits or iron pipes; and Messrs. Johnson and Phillips themselves believe that the only other system that could compare on the score of efficiency and permanency with the Brooks mains, is that in which the cables highly insulated with India rubber or gutta-percha are drawn into iron pipes kept full of water.

Experience in America for a period of at least ten years has already demonstated that, in the Brooks telegraphic and telephonic mains, the cost per wire in a cable of many conductors is less than the cost per wire insulated with gutta-percha or India rubber, even including the additional charge of conduit pipe and boxes, or other device.

It has also been abundantly proved at Charlton that mains for the distribution of electric light and power will stand the severest tests that are ever likely to be required with even far higher voltages than at present are anywhere employed.

Probably one of the largest fields of usefulness for the Brooks mains will be in connection with the high-pressure three-wire alternate current distribution for lighting, and for alternate current motors, of which the installation to transmit several hundred horse power a distance of 12½ miles at 25,000 volts, now being erected at the Oerlikon Works, Zurich, is the first and most noteworthy example. Examples of the use of underground transmission in towns where overhead wires can not be employed will probably not be long in being seen in practice. The details of the Brooks mains for this system have already been carefully worked out.

The general scheme of the use of the Brooks system for public lighting at Hongkong is shown in Fig. 9, where the overhead lines are seen coming to tall posts bearing insulators with an arc lamp above the wires. In the crowded streets, where overhead wires would not be advisable, the high-pressure wires for the arc lamps in series, carrying 2,000 volts, are taken down and under the streets in iron pipes filled with the Brooks liquid insulation, are then run along the streets and up a series of lamp-posts—one of which is shown in the illustration—and then up vertical pipes again to the overhead wires.

The details of the junction box and insulator for the top of the posts, where the overhead and underground wires are connected, have been carefully worked out by Messrs. Johnson and Phillips, and are shown in Fig. 10. The wires are pulled through the box, and the ends soldered together and insulated, and a

screw cap fixed over them. The overhead line passes to an insul r specially adapted for oil insulation. The underground mains descend on ·inary pipe, and the whole is filled up with oil insulation.

We now pass to another and important application of the Brooks system.

The prominence that is being given to high-pressure three-phase alternate-current transmission in Germany and Switzerland will make doubly interesting the details of the Brooks mains which have been worked out by Messrs. Johnson and Phillips, in conjunction with Mr. Gilbert Kapp, for the underground transmission of these currents, to be used, it is expected, at an average of some 20,000 volts.

The drawings are almost self-explanatory. The junction box, shown in Figs. 11 and 12, is for the distribution in a number of directions of the three-phase current. Each pipe contains a three-strand cable, the strands of which on entering the junction box are separated and led through glands to separate terminals, or omnibus bars, to which the other distributing cables can be connected. Provision is made for fuses, if desired, between the mains and branches within the junction box. Now that the enormous pressures, at one time considered beyond control, are being handled without much greater trouble, save for insulation, than the currents of ordinary voltage, a system such as this of Mr. David Brooks' should become more and more valuable to electrical engineers. More extensive applications for it for transmission of power, or for distribution of light, will doubtless be recorded in the near future.

THE EDISON SYSTEM.

The general features of the Edison system have been too widely published to need further description at our hands. As now developed, what is known as the "three-wire system" is mainly used by the Edison companies. In this system three insulated copper rods are placed in an iron pipe, from which they are insulated. The system is a sectional one, and each tube is as complete when it leaves the factory as a rail from a rolling mill. Like a rail, it needs only to be joined to other similar units to become a part of a continuous line.

In the three-wire system of distribution, the conductors, whether overhead or underground, are divided into two classes, viz: feeders which run from the dynamos to center of distribution, and mains which radiate from center of distribution and loop the ends of the feeders together, constituting the second class. All taps to supply customers with electric current are taken from the mains. Electric tubes are accordingly divided into feeders and mains. A main electric tube, or, more briefly, a main, has three insulated copper conductors of equal size. A feeder electric tube, or feeder, has two principal conductors and one smaller conductor to serve as a neutral wire. A feeder also has three insulated cables of seven No. 19 B. W. G. wires each. These small cables form independent circuits from the station to the point of distribution, and enable one to read in the station the electrical pressure at the outside end of the feeder. Hence these lines are called pressure wires.

The system of numbering electric tubes is based on the Edison wire gauge. The size of any tube is the number of thousand circular mils in its positive or negative conductor. Thus a rod one-half inch diameter has 250,000 circular mils area, and a tube having three such rods would be a No. 250 main.

Four sizes of pipe are used in the standard Edison tubes, and the range of sizes is given below. All pipe diameters are nominal inside diameters:

80,000 circular mils to 120,000 circular mils in 1¼-inch pipe.
150,000 circular mils to 300,000 circular mils in 2-inch pipe.
350,000 circular mils to 600,000 circular mils in 2½-inch pipe.
700,000 circular mils to 1,000,000 circular mils in 3-inch pipe.

The copper rods are all 20 feet 4 inches long, and project from each end of the pipe. All 1¼ and 2 inch pipes are cut 20 feet long, allowing 2 inches projection of copper; 2½-inch pipes are cut 19 feet 10 inches long, giving 3-inch projection; 3-inch pipes are cut 19 feet 9 inches long, giving 3½-inch projection of rod. The rods are drawn to exact gauge of the finest and purest lake copper, and have a conductivity in excess of 98 per cent. The pipes are the best grade of lap-welded steam pipe, free from imperfections and of full weight.

Fig. 1 shows sections of standard sizes of mains and feeders. Two additional small mains, No. 67 and No. 41, are made in 1½-inch pipe for service work only.

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*Mr. Brooks died at Philadelphia, June, 1891.

In making up a tube the ends of the copper rods are first chamfered and tinned and the pipe thoroughly cleaned on the inside. Each rod is wound separately with a prepared rope, and the three rods so wound are made into a triangular bundle and wound with a fourth rope. This bundle of rods bound with rope is slid into the pipe, which is afterward filled with insulating compound. A special process insures an entire absence of air bubbles and the ends of the pipe are closed with rubber plugs. The tube is now tested by means of a delicate Thomson reflecting galvanometer. The tube after testing is painted to preserve the iron from rust, and is ready for shipment.

In order to complete the system there is required a means of joining the ends of the conductors in consecutive tubes, and of protecting and insulating such a joint when made.

Fig. 2 shows a joint between two main tubes partially completed. The side on the neutral joint is in position ready to solder. The top coupling joint is being slid into place, while the bottom coppers are untouched.

In Fig. 3 is shown a feeder joint partially completed. In feeder tube joints, after the copper rods forming the main conductors are joined, the pressure wires referred to in the definition of a feeder are connected by soldering a wrapped splice, and then taping over the splice with insulating tape. The coupling joint which connects the rods is made of pieces of flexible cable with sockets cast on each end. These sockets are drilled to fit easily over the rods which the joint is to connect.

Fig. 4 shows a number of sizes of coupling joints in different views. Shorter and longer joints are made for use in turning corners, and are called elbow joints. Various combinations of elbow joints for different angles are given below. A branch or service joint is for use where a tap is taken from a main line to supply a customer. They differ from other joints in having a socket on one end only, and a round pin-like projection or tenon on the other end of the piece of cable. The tenon fits into the holes noticed in the faces of the sockets of coupling joints, Fig. 4.

Fig. 5 shows the branch joints and link used on all service connections up to and including 120,000 circular miles area.

Having described the joints for straight lines, bends, and branches, we come now to their protection and insulation. For protecting straight work, an iron box, made in two halves and called a coupling box, is used.

In Fig. 6 is shown a ball clamp, which is for holding the tube, as in Figs. 2 and 3. These clamps are split collars, and grip the tube firmly. The sockets at each end of the coupling box form with the ball of the clamp a ball-and-socket joint. Ball clamps are made in three styles for use with 3, 2½, and 2 inch coupling boxes. The 2½-inch style is made in three sizes for use with 2½, 2, or 1½-inch pipe. The 2-inch style is made in two sizes for 2 and for 1½-inch pipe. A clamp for use on a pipe whose inside diameter is less than that of the largest tube used in the coupling box is called a reducing clamp. Thus a 1½ inch pipe, when used with a 2½-inch coupling box, takes a 2½ by 1½-inch reducing-ball clamp.

A 2½-inch coupling box is shown in Fig. 2. The 3 and 2 inch coupling boxes do not differ, except as to size. The two halves of the box are bolted together by bolts through the flange. In the top half is a round hole closed by a cast-iron cap. Through this hole the box is filled with hot insulating compound, which surrounds and insulates the copper rods, the joints, and the tube ends. This compound does not grow brittle on cooling or with age, but remains plastic even at temperature below the freezing point. An elbow box 2½ inches, 90°, is shown partially inclosing an elbow joint between two main tubes in Fig. 8. The 55° and 30° elbow boxes are similar in general design. All elbow boxes allow a range of 18° on either side of their mean position. Thus any angle between 37° and 73° may be made with a 55° elbow box. The 3-inch elbows differ from the 2½-inch only in being larger. All elbow boxes take special clamps called cup clamps. These clamps have spherical surfaces like ball clamps, but are designed to give a greater range of movement to the ball-and-socket joint formed with the elbow box. The clamps for the 3-inch elbow boxes are similar to the 2½-inch cup clamp shown in Fig. 8. All boxes, whether coupling or elbow, have a round hole in the top half through which they are filled with compound. This hole is closed by a round iron cap, which is locked securely in position by turning it through one-quarter of a revolution. This cap, shown in Fig. 9, makes a dirt-tight but not air-tight joint, and is called a ventilator top.

Having disposed of the main line we come to the branches leading to the customer's premises, or, as they are commonly called, the services. These are short lengths of tube which tap the main line by means of a three-way box called a

of the first main E E. and the other piece being fixed on a line with the second main cable and projecting upwards to the same height as the copper pieces thereon.

All that has now to be done is to place solid lengths of copper bar, L L, across the mains, securely fastened by nuts and bolts, the positive main E E to the distributor ⊕, passing over the other distributor without touching; and the negative to the negative distributor D, passing over the positive without touching.

The cables and the connecting pieces are then insulated by semivulcanized material, and then protected by tape; the inner box is filled in with molten fine bitumen, and the cover placed on. The outer box is then similarly filled in with bitumen, thus forming a perfect protection from moisture getting into the joints in the inner box. The last lid is placed in its place, and the whole covered up with earth and finished off level to the road with the same paving as the roadway itself.

In certain cases these four-way boxes are left without the inner space being filled in with bitumen to allow junctions of house mains to be easily made. This type of box is, however, designed to be filled in solid and permanent, and, if accessible, junction boxes are required for the junction of house-service mains or of a branch distributing main, a solid main fuse is used in a fuse box with accessible manhole. These accessible fuse boxes are applicable to either system, solid or otherwise, and therefore need not be again described.

We now pass to the system of connecting mains and feeders in an ordinary central station network. In an extensive area of supply, the mains, both of feeders and distributors, will spread over a considerable area. Two things may happen to necessitate change in the connections. In the first place, a fault may be found, in which case tests would require to be made, and a certain length of cable might be required to be cut out of circuit; and, again, the demand for current may be altered in certain districts, and the points at which the feeders should feed into the distributors may require to be changed to some other point. It will be seen from this that a ready and rapid method of disconnecting mains, and of connecting up others in their place is desirable on both grounds.

A simple yet ingenious method is used in the Callender system, shown in plan and section in Fig. 6, which illustrates a single pole junction box, having the ends of a network of four subsidiary mains connected to the feeding main. The principle of the arrangement is that of having, on the ends of each main, lugs of solid copper, which can be screwed to a copper "omnibus" bar, and so arranged that each, if unscrewed, can be swung round off the bar, and thus disconnected at once, without interfering with or touching any of the others.

The way in which this is carried out is easily seen in the illustration. A double cast-iron box similar to those already described for the simple four-way junction has leading into it the ends of the main M M. To each of these is sweated or soldered copper socket pieces, P, having a broad solid lug of copper, L, which is pierced for a bolt. The broad solid omnibus bar O B is bolted closely to these lugs, having a short piece of similar thick copper, S P, through which the full connection across is made. It can easily be seen that by unscrewing this swing piece, S P, and swinging it back, the main M becomes disconnected.

In the same way the ends of the distributing mains are led into the junction box, each having its end bared and a socket piece fastened thereto. Short swing pieces, S P, are then bolted between the omnibus bar and these distributors. If occasion arises to alter the connection, or to cut off the supply from a certain district, all that is necessary to do is to unscrew one bolt and then move the swing piece round clear of the bar. The position of these pieces is arranged so that each can be swung round at its center without the necessity for touching or removing any other connection.

The accessible junction boxes are fitted with an india-rubber gasket round the joint of cover, and are screwed down with a phosphor bronze set screw.

The buried junction boxes are used under roadways and are covered with the ordinary pavement without cover plate, the paving being lifted if it becomes necessary to examine the connections, in which case the bitumen can be easily removed by the use of a heated tool.

Ordinary sizes of cables are: For feeders $\frac{19}{44}$, equaling 1 square inch sectional area; $\frac{19}{44}$, equaling six-tenths of an inch section area of copper, and both can be laid up to 250 yards length; for heavy feeders $\frac{37}{44}$, equaling 1¼ inches sectional area, laid in 150-yard lengths. The distributors are usually $\frac{7}{44}$ cable, one-quarter of an inch sectional area, or $\frac{19}{44}$, one-tenth of an inch sectional area, laid according to circumstances, up to 600 or 700 yards. The latter size is usually employed for the house-service lines.

The Callender solid system is particularly applicable to high-tension systems for arc lighting in series where the mains have to be led from lamp to lamp under the streets, and the strength of current remains constant without necessitating increase of cable section, even if the number of lamps is increased.

Sections of mains for high tension are shown in Fig. 7, where the sizes of troughs for four and for six highly insulated $\frac{7}{8}$ cables are given. The process of laying is exactly the same as that previously described, with the exception that the troughs are always covered with a cast-iron cover, or in particular places with steel covers, to afford absolute security against accidental interference by picks of other workmen.

The method of connection of the arc lamp-posts in series is seen in section and plan in Fig. 8, where a junction box at a street corner is shown. The cables are laid in the trough with sufficient spare length to go up the lamp-post without joint, a junction box being let in under the pavement and covered with a steel-plate lid. These high-tension mains can be easily laid in lengths up to one mile without joint.

The following is a fairly comprehensive list of central stations at which the Callender and Callender-Webber mains have been laid down:

Chelsea. The Chelsea Company. Draycott Place station, Clabon-Mews station, complete set of feeders and distributers.

South Kensington. The Chelsea Company. Egerton-Gardens central station, complete set of feeders and distributers.

Whitehall. Metropolitan Company. At Charing Cross.

Strand. Electricity Supply Company (late Gatti). Bull Inn-Court station, and along the Strand, Charing Cross district.

Liverpool. Liverpool Electric Company. Three stations, comprising the complete district between Lime street and the docks.

Birmingham. Birmingham Company. All the central portion of the city.

Bath. Mr. Massingham. Arcs for the town lighting. Incandescent supply for private lighting.

Brighton. Network for corporation plant.

Le Mans, France. Central station network.

St. Austell. Central station for private supply.

Victoria Station. Edison and Swan Company. Installation for the railway station.

Law Courts. Crompton. Law Courts building.

Temple. Edison-Swan Company. House lighting in the Temple.

Westminster. Westminster Company. Many miles of Callender-Webber casing laid in conjunction with Crompton mains where culverts were unsuitable.

Northampton. Crompton & Co. Several lengths of main, laid both on Callender-Webber and solid system, in conjunction with Crompton culverts.

In addition to which are a large number of mains for isolated installations, amongst which are: Buckingham Palace (Her Majesty, Queen Victoria), Hatfield House (Lord Salisbury), Normanhurst (Lord Brassey), and many others.

THE FERRANTI SYSTEM.

The following from the London Electrical Engineer, under date of July, 1890, fully describes the Ferranti system. It was at that time under process of construction. The article of Mr. Caryl D. Haskins, read last February before the National Electrical Light Association, gives further details. We are informed that, at this time, the system is completed and in full operation, with satisfactory results. The fact that the alternating system is specially applicable where the light is furnished remote from the source of power, makes it of special interest in the future electric lighting of the city of Washington.

Among electrical engineering enterprises at the period of early development of the industry in England, the large central high-tension system at Deptford will remain noticeable, not only on account of the largeness of its conception, but also on account of the remarkable difference of opinion and statements of fact which have arisen about it.

We must first of all remind our readers that the scheme at Deptford comprises two engines of 1,500 horse power and two engines of 10,000 horse power, driving Ferranti 10,000-volt alternate-current dynamos for transmission of current through mains to London, and transformation there to currents of 2,400 volts, as for some years distributed from the Grosvenor Gallery. Of these engines, one of the 1,500 horse-power engines is erected and has been running since November, last year. This is the only engine running at Deptford at present. A second

one is already erected, but is not yet used for supply, and two 10,000 horse-power dynamos are in course of construction, and parts of the immense 42-foot fly-wheels, the 27-ton shaft, and the huge cranks are being turned up in machine tools erected inside the station.

It will be remembered that the Farranti concentric mains not being ready, the company laid and run from Deptford to Charing Cross temporary cables of special manufacture. These, however, were found to be unable to stand the high pressure of 10,000 volts, and a reduction of 2,500 was made, the inner conductors only of the two cables being used.

At this pressure current was transmitted for some time from Deptford to the Grosvenor, where it was used together with the current from the Grosvenor dynamos. The arrangement under these conditions is shown in the diagram, Fig. 1. It is hardly necessary to remark that such an arrangement reduced by half the output that could be transmitted at even the half pressure before used of 5,000 volts, and at this lower pressure the whole lighting of the present installation of 38,000 lamps could not be supplied from Deptford.

An ingenious arrangement was therefore adopted and has been running for some weeks, by which, though the pressure to earth from the cables is only 2,400 volts, yet the total pressure of the current transmitted is 5,000 volts, under which conditions the whole lighting can be, and has been, done from Deptford, the Grosvenor acting merely as reserve. This arrangement, which will doubtless greatly interest our readers, is shown in diagram in Fig. 2. The Deptford dynamo is run at 5,000 to 6,000 volts, and one pole of the dynamo is put to earth. But instead of transmitting direct to the Grosvenor, the current is put through transformers at Deptford, transformed and transmitted to London, still at 5,000 to 6,000 volts. Now, as will be seen by the diagram, though the total pressure between the mains is 5,000 volts or more, the difference of potentials between each of the cables and earth (the insulation being kept the same in both) is exactly what it was before in the case of one only, viz, 2,400 or 2,500 volts. In this manner the danger of sparking to earth is overcome, and double the energy is transmitted.

The exact arrangement of the transformers is indicated in diagram, Fig. 3. Four transformers are arranged with their low-tension coils in series in the dynamo circuit with a high-tension fuse on one pole and the other dynamo pole being put to earth. On the other side of the four transformers their poles are connected in parallel, passing through two high-tension fuses and so into the main cables to London. So that each set of four transformers transforms from 5,000 to 6,000 volts, with three fuses in circuit, and one pole on the dynamo side of the transformer being to earth. Three sets as above are arranged at Deptford, each set with its own main switch and three fuses, so arranged that one, two, or three circuits can be thrown in at will, according to requirements at London as intimated by telephone.

These diagrams are reproduced from those kindly given to us by the company's engineers.

Accurate records are kept from day to day and from hour to hour of the current and pressure registered. The amounts now registered in daily running show currents of from 30 up to 120 amperes at pressures from 5,000 up to 6,000 volts. This, it will be observed, is already nearly two-thirds the pressure of 10,000 volts ultimately intended to be run. The main laid was originally intended for this higher pressure, with a loss in transmission of 8 per cent. The current, as at present sent, is at half or two-thirds only of this, and, of course, the loss in transmission is naturally somewhat higher at the lower pressure. But it is interesting to note that, notwithstanding this extra loss at present, the actual cost of manufacture per unit delivered at London from Deptford is stated by the engineers to be considerably less than the cost of manufacture at the Grosvenor.

For the manufacture of the Ferranti concentric mains special machinery has been erected at Deptford, and is now in full working order. Some 2 miles or so of main are now being turned out every week, and on our visit we were shown the entire process from beginning to end.

The main is of section shown in Fig. 4; first, a small thick hollow tube of copper; then the main insulation; over this the outer hollow conductor of thin copper tube; then another thin coating of insulation; and, lastly, a steel outer casting for prevention of mechanical injury.

The first process is that of insulating the inner conductor. Copper tube of the required section (one-fourth of a square inch area) and size is cut off by a circular saw to a length of 20 feet. This is taken to a long trestle, and long strips of

brown paper, 20 feet long and some 4 feet wide, are gummed at one edge to the copper tube. This is now taken to the covering machine. This insulating or covering machine has been specially designed and adopted for the manufacture of these mains, and works with great ease and simplicity. At one side another machine prepares specially coated paper. This machine is nothing more than a long hot plate, coke heated almost to the scorching point, over which long strips of brown paper, from huge rolls like that used in printing newspapers, are drawn by rollers. On the hot plate all moisture is driven out, and the strip of paper then passes down, into, and through a hot caldron of special black oil or wax, coming out soaked in this wax, and is then dried and cut off into 20-foot lengths. These lengths are carried to the insulating machine first mentioned and laid in heaps underneath a long metal table in front of this machine. The copper tube is slowly rotated, and six or seven sheets are then wound on till the inner tube is covered as thickly and tightly as possible.

The next process consists simply in slipping this 20-foot length of insulated tube into a second hollow tube of thin copper, which forms the outer conductor, and which is of corresponding total section to the smaller and thicker inner one. Then the whole is passed through a large draw plate, and the outer tube is carefully drawn down tightly over the insulation.

Next, the insulating process is repeated on the larger conductor—gummed brown paper, inserted sheets of prepared waxed paper, hot wax bath, rolling, and tapping.

Finally the first stage of the manufacture is completed by slipping on the exterior protective casing of thin steel tube. In this steel tube is a small hole drilled in the center previously and through this hole hot wax or bitumen is forced in by a force pump, driving out all air at both ends and forming a compact and solid mass.

Next comes the most important and interesting part of the manufacture of the Ferranti mains—the construction of the joints. When we remember that some 6 or 7 miles of this cable are to be laid in each main, that three mains will be laid from Deptford to London at once, and that a joint comes every 20 feet, it is evident that the joint is the point at which greatest care must be taken to have perfect insulation and perfect protection against creeping or sparking of the 10,000-volt current.

The joint is made in the following neat and simple way: First the cable, as manufactured in lengths, is taken to specially adapted turning lathes. There one end of the main is turned carefully and smoothly down in a taper of 6 inches length, from the center-conducting tube backwards to the outer conducting tube, as shown in Fig. 5. This turning is carefully and accurately done to gauge and by tools set at the required angle, and is polished off to a smooth surface.

The interior of the inner copper conductor is accurately bored out and smoothed, and then a length—some 18 inches or so—of turned solid copper rod is forced into this, a tight metallic fit, as in Fig. 6. Then a sleeve of thin copper tube, slightly larger than the outer conductor, is slipped over the end of this outer conductor, left here for several inches for the purpose, and is then corrugated down upon it with three corrugations, as shown in Fig. 7. This corrugation is an essential part of the construction of the Ferranti main, and is a neat, simple, and effective method of securing both good metallic contact and strong mechanical juncture. The method of corrugating on is carried out with a smooth, polished steel wheel and grip, and it is used, as will be seen, several times in the making of the joint. This finishes one end of the length. The end is filled up with a piece of greased waste and capped with a tin cap ready for transport by railway.

The other end is treated in a corresponding way to form an exactly opposite contour, into which the end of the next length can be pushed tightly. The insulation here is turned out in a hollow-coned or taper form from the exterior inward for the length of 6 inches, as shown in Fig. 8. This turning is also carefully done with tools set at the required angle, and smoothed or polished, and the ends meant to join are tested together to see that they fit.

The main is now ready for actual jointing. In making the joint the ends are pushed together, the solid inner rod, which projects from one end of each length, going into the interior of the inner conductor of the next length. Previously to the jointing, a joint cover, composed of two pieces, Figs. 9 and 10, is slipped some distance back over the main. This joint cover comprises a sleeve or tube of waxed paper insulating material, and a length of steel tubing formed like a reducing junction, as shown in the figure. To make the joint the ends are pushed together as mentioned, and then are forced together by hydraulic pressure till tight home. The joint is now heated, and the smooth taper surfaces of the joint

stick together. After this the copper sleeve, which has now slipped forward over the joint, is corrugated down in the manner before explained upon the other side of the main outer conductor, thus forming metallic connection with this outer conductor; when this is accomplished the paper insulating sleeves, with the exterior steel protecting piece, Fig. 10, are slipped forward over the joint. Hot wax or bitumen is forced in to fill up the space, and finally each end of this steel-jointing piece is corrugated down upon the steel protecting tube of the main itself, so forming a compact solid joint.

Thus the joints are made. About two-thirds of a mile of this main has been laid and practically tested since April 19. Pressures of 16,000 volts to 18,500 volts have been kept on this length, at intervals as the dynamo has been running, ever since. Since then fresh lengths have been added from time to time, each length being tested as it was put on, with 18,500 volts. No breakdown whatever has occurred, even in testing. The actual working current has not actually been passed through at this pressure, owing to the evident difficulty of getting rid of, or absorbing, this enormous energy. But this length of main has been tested with 400 ampères of current at a low pressure, and immediately after this test the full testing pressure of 18,000 volts was turned on with equally satisfactory results. One part of the main, where it entered the Deptford works, has been twisted and bent into wavelike form to show that bending can be done without damage to the cable: and also to test this method of allowing for expansion without the necessity for special expansion joints. We shall await with impatience the actual working of these mains in London, but it will be seen that the particulars we have been able to give show great promise of a satisfactory method of dealing with the enormous tensions with which Mr. Ferranti has associated his name at the Deptford central lighting station.

THE FERRANTI SYSTEM.

[By Caryl D. Haskins.]

I keenly appreciate the compliment which your committee has paid me in naming me to appear before you to-day to read a paper.

I fully realize that much is expected of me, and I believe I even more fully realize my inability to handle the subject with the completeness which I could wish.

My connection with Mr. Ferranti was not of long duration, and it is now some time since I severed my connection with him, so that my information, whilst pretty complete, so far as it goes, is not as thoroughly up to date as it should be.

The Deptford station was far from finished when I left London, and 10,000 volts generated direct from the dynamo was still a matter for surmise and conjecture.

Under these circumstances the best thing I can do, I believe, will be to take up each feature of the system separately, and describe it to you in its various forms and applications as thoroughly as I can. Starting with this plan in view, I have arranged my paper under the following heads:

Methods of distribution, Ferranti dynamos, Ferranti transformers, fuses, etc., and the Ferranto meter.

Starting then with Mr. Ferranti's methods of distribution, I will deal first with the old and somewhat famous Grosvenor Gallery station, from which current, at a pressure of 2,500 volts was distributed throughout the most wealthy portions of London's west end by means of overhead wires.

At the Grosvenor station there were two dynamos, each of 625 horse power nominal. These machines I will describe later on.

From these generators the circuit was carried to five double-pole, double-throw switches, each having a break of 2 feet and breaking both sides of the line at once.

Each of these switches represented a circuit, there being five circuits in all run from the Grosvenor station. It will readily be seen, therefore, that the switch board of this station, which distributed light to no less than 35,000 lamps, was an exceedingly simple affair; yet, with their five switches, any desired combination of machines and circuits could be made.

It has quite frequently been stated, I believe, that these two machines at the Grosvenor were run in multiple. This is in no sense true, though, since the removal of these dynamos to Deptford station, they are to be connected in this manner, I understand.

From the five main switches the current was carried through Ferranti plug fuses of rather peculiar construction, having a break of 2 feet. These fuses I shall describe later. From the fuses the circuits were carried on ordinary wiring to

an overhead distributing pole. From this center the wires branched in five directions, being carried over the house tops and not through the streets, as is our custom in America.

Stranded steel cables seven-sixteenths B. W. G. are stretched from pole to pole, and from these cables the mains are supported at frequent intervals by means of leather thongs or slings, thus saving undue chafing and straining of the conductors. This method of supporting the mains presents many marked advantages, the wear of insulation is reduced to a minimum, and the liability to a ground is very much diminished. The leather slings stand the wear and weather exceedingly well, and renewals are much less frequent than would be expected, especially if one take one's footwear as a basis for calculation.

All streets are crossed at right angles, and no difficulty is experienced with the ubiquitous telephone man.

Contrary to the custom in this country, the primary wires are generally run into the house to be lighted, where they are connected to the transformer, a Ferranti fuse being placed in the circuit.

The secondary circuits are of 50 or 100 volts pressure, as may be required, and the house wiring is quite of the usual style, having a principal secondary fuse at the transformer and a Ferranti recording meter in series with the lamps.

The Grosvenor Gallery, as a generating station, is now a thing of the past. It has been reconstructed, and is now one of the four transforming centers of the Deptford system, which draw their energy at the phenomenal pressure of 10,000 volts from the machines in the great station on the Thames.

This heavy pressure is reduced at these central points by means of large transformers, and is distributed over the London housetops at an E. M. F. of 2,500 volts in the manner I have already described, the only difference here being that these overhead mains are on a secondary instead of a primary circuit, and the house circuits become tertiary instead of secondary.

The portion of the Ferranti system of distribution which has given rise to the most interest and which has been most talked of is the present primary circuit, extending from Deptford to the four central distributing stations in London.

Many curious and wonderful letters regarding this have appeared in our journals at various times and have given rise to much confusion and many wild conjectures, whilst the real facts of the matter are, I believe, but little understood.

The shape and principle of Mr. Ferranti's concentric main is familiar to all, but a few words descriptive of it may not be out of place here.

Over a copper tube, about 1¼ inches in diameter, insulation is wound in the form of a stout manilla paper, thoroughly saturated with a special insulating compound. This insulation is wound on to a thickness of one-half inch by a machine specially designed for the purpose by Mr. Ferranti; over this insulation a second copper tube is placed, of the same sectional area as the inner one, and this is drawn down till tight.

The cable is made in lengths of 20 feet, and stands static tests of immense pressure. Special plug and expansion joints are provided for connecting the lengths, which are also thoroughly reliable.

The original intention was to lay these mains with the outer tube directly to earth throughout its entire length, thus rendering the system absolutely safe, since only one side of the circuit could be touched by the hand, and there would be no difference of potential between this and the ground.

Alternating circuits and grounded telephone lines do not agree, however, and the law demanded that the Ferranti mains be laid duly insulated from earth; this is therefore done, but one terminal of the machine is still connected to ground, and comparative safety is the result, since it will readily be seen that to short circuit through the body it would still be necessary to touch the inner tube of the conductor. This would necessitate cutting through the outer tube and insulation, which would mean a short circuit from tube to tube, through the cutting instrument, a dead short circuit on the machine, certainly, but perfectly safe for the meddler.

At the collector boxes of the machines an accident is impossible, since the collectors are inclosed within an iron box, the lid of which is magnetically locked by the exciting current, nor can the machine generate when the box is open, since the exciting circuit is not complete till the box is closed.

Unfortunately time was an object in the starting of the Deptford station, and much contract-made cable was laid. The greater part of this was the lead-covered cable so frequently mentioned. This was not of the concentric pattern, but an ordinary stranded cable. I understand that it was guaranteed to stand considerably above 10,000 volts, but after being laid it was found not to stand 10,000 at all, and to give but poor satisfaction even at 5,000.

This unfortunate trouble has given rise to much talk, and has been scarcely well understood by the general public.

Several other kinds of cable were tried, but gave equally unsatisfactory results, and all mains have doubtless by this time been replaced by the Ferranti concentric cable, which stands the pressure perfectly and gives most satisfactory results.

Of the various expedients to which Mr. Ferranti had recourse during this trouble with the cables I am not prepared to speak, first, because I am not fully informed regarding them, and, secondly, because they form no portion of the Ferranti system of distribution. They were simply makeshifts, necessitated by an unfortunate happening and by lack of time, and they have probably given rise to more discussion, both in and out of the papers, than has the system itself.

I will now pass on to a description of some typical Ferranti dynamos. First among these, a few words are due to the original form of Ferranti alternator, which, while it is no longer manufactured, still, without doubt, was a machine of marked efficiency and great originality.

The characteristics of this earliest dynamo are, I think, about as follows: The figures are not based upon my personal experience, for the machine was out of date long before my time, but upon various fragmentary notes from my pocket-book and a generous quotation from Thompson's "Dynamo-Electric Machinery."

As in the Siemens machine of similar type, the fields formed, as they do now, "two upright circular crowns of electro-magnets with opposing poles." There were sixteen magnets on each side; thirty-two in all.

The peculiarity of the machine lay in the armature, which consisted of a series of zigzag loops, eight in number, wound or folded one layer upon another, and separated by alternate ribbons of strip insulation of similar width. The winding was in three multiple circuits, each strip making ten turns around the zigzag coil, thirty layers of winding in all.

Each of these three coils is connected at one end with a solid star-shaped brass boss, which, bolted together from either side through the loops of the zigzag coil, form a solid center for the disk armature, and at the same time connect directly with one of the collector rings, the three coils all again uniting in an inner star-shaped piece of brass, which in its turn communicate with the second collector.

The disk armature was 30 inches in diameter and one-half inch thick. Its extreme thinness permitted the magnet poles to be brought very close together, enough space only being allowed to insure safe clearance. The natural result of this was a very efficient field.

On these bundles of irons, at the portion wrapped with insulation, is wound the secondary, which is in its turn wrapped with insulation; on top of all this the primary is slipped in the shape of a number of coils, wound elsewhere on former blocks. These coils are slipped on, one by one, and separated from another by washers of shellacked cardboard.

The projecting irons are then turned back over the coils from each end, lapping each other, first one way, then the other, like shuffled cards, and the last two are fastened off by a simple double L or tinsman's joint. Half of each bundle is turned back in each direction, up and down, forming complete magnetic circuits in two directions.

The transformer is extremely convenient in case of repairs, when the irons are really straightened out and burnt primary coils replaced.

It seems, however, to have several marked defects, the flat side of the lamination is presented to the penetration of the lines of force, which, according to Kennedy, is incorrect construction, and the transformer is inclined for this reason both to heat rather badly, and to hum, the latter trouble being partly due doubtless to the fact that the iron can not be held so firmly in this style of converter as in the more common type, where the iron forms a solid block.

The transformer is inclosed within a cast-iron shell, from which it is insulated, and into which the primary and secondary terminals are fixed by means of the Ferranti sulphur insulation.

These converters are made in five sizes, 25, 50, 100, 150, and 200 lighters. The large transformers for reducing the 10,000 volts of the primary to the 2,500 volts of the street circuits are of the same construction as these I have just described, the insulation being, of course, increased to bear the enormous pressure.

This is not the original transformer used by Ferranti; that was the Gramme ring type, and rather more efficient than the present one, I believe, but scarcely practical from a mechanical standpoint.

There now remains to describe only the Ferranti meter, a most ingenious recording instrument, largely used in connection with Mr. Ferranti's London cir-

cuits. This meter consists of a coil, of a few turns, in series with the lamps, which passes around a core of soft iron, and terminates in a composition metal ring, which is split to prevent Foucault currents, and is bolted onto a soft iron base, being, however, insulated from it. Thus it will be seen that the ring, the base, and the soft core around which the coil passes (the lower portion of which is burnt or cast into the ring also), form, respectively, sides, bottom, and top of a hollow and tight trough; the iron is continued from above the coil, by means of a horseshoe-shaped laminated piece of iron which passes down outside of the coil and makes contact with the base; thus we have a magnetic pole at the top and bottom of the trough.

This trough is filled with mercury, making contact with three-fourths of the inner circumference of the ring, and the center of the base. The current entering the coil, passes around it to the ring, and from the ring through the mercury to the base, on which is the other terminal.

Under the combined influence of the magnetic field and the current passing through the mercury from center to periphery and vice versa, the quicksilver is caused to rotate.

A shaft passes from a jewel in the base, through a small hole in the iron core to a train of wheels at the top; on this shaft is an aluminum fan suspended in the bath; this is all balanced so nicely that it actually floats in mercury.

Now, since the resistance to rotation due to friction is approximately proportional to the square of the speed, and the turning moment is proportional to the square of the current, the number of revolutions performed in a given time is a measure of the current which has passed through the meter during that period.

Owing, however, to the rule of friction not following this law absolutely, and owing to the additional and irregular friction of the gear, a sensible error is introduced. This difficulty is overcome by placing a shunt coil of high resistance around the series coil, which secures an excess of electro-magnetic action, when the friction is greatest in proportion to the torque, thus assisting the low loads.

The meter is very accurate, and has a quite wide range, 1 to 50 ampères being the capacity of the 100-volt instruments; it is equally serviceable on direct or alternating circuits of any frequency.

This meter, while undoubtedly accurate, has many very apparent weak points however; the mercury volatilizes quite rapidly, especially when the instrument becomes warm; the meters must always be kept upright or their contents will spill, and they can not be carried from place to place without being emptied and refilled, which, as the quantity of quicksilver varies, is apt to introduce errors. In view of these troubles, Mr. Ferranti is now also manufacturing and using a number of meters of small capacity, similar in principle to the well-known Shallenberger instrument, which are sufficiently accurate for general use; these are manufactured under the English patents of Mr. Wright, one of Mr. Ferranti's staff.

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Plates 1 to 8, inclusive, Lynch Lake rectangular glazed clay conduits.
Plates 9 to 14, inclusive, McDonald creosoted wood duct system adopted in Philadelphia.
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Plates 17 to 21, inclusive, Interior conduit.
Plates 22 to 27, inclusive, Johnstone system.
Plates 28 to 34, inclusive, Callander system.
Plates 48 to 50, inclusive, Edison system.
Plates 35 to 39, inclusive, Crompton system.
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Plate 46, Westminster system.
Plate 47, Ferranti system.
Plate 51, Buda-Pesth Electric Railway.
Plate 52, Toronto subway.
General plan of conduit system proposed.
Maps of Western Union Telegraph Company's lines.
Map of telephone lines.
Map of electric-light companies' lines.
Map of District wires of fire-alarm and police-signaling service.

Brooks System

Fig. 1. Brooks System of Underground Cables in Iron Pipes

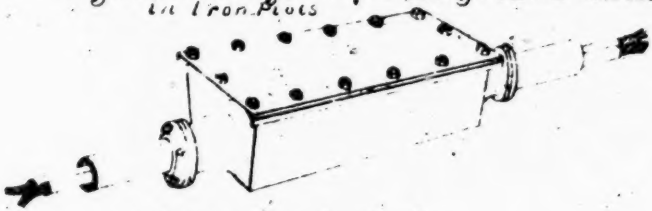


Fig. 2. Drawing in Box.

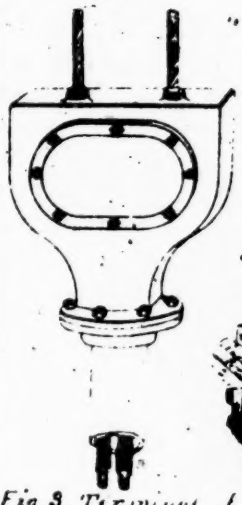


Fig. 3. Terminal Box

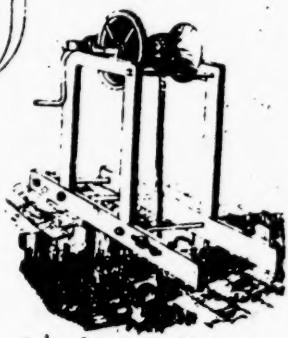


Fig. 5. Winch for Drawing in Cables

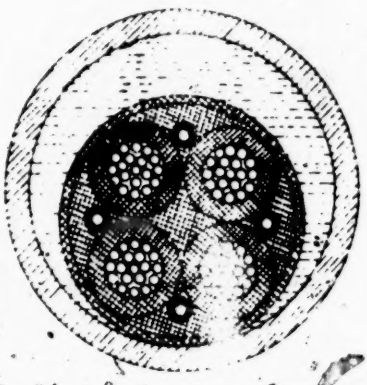


Fig. 4 Section of Underground Insulation

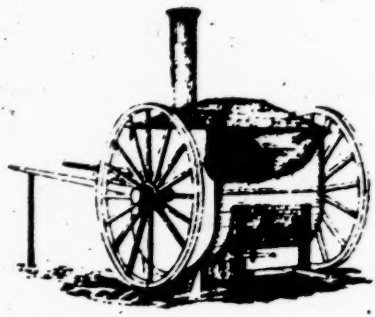
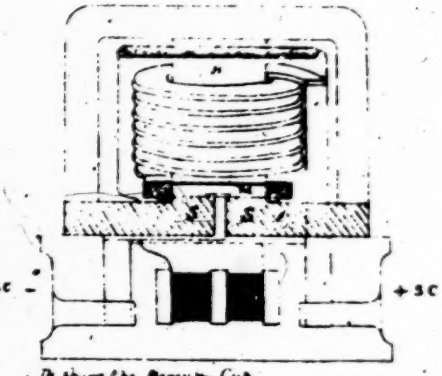
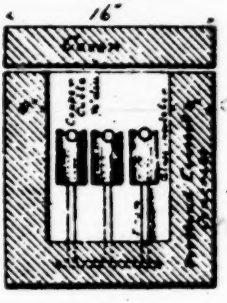


Fig. 6. Cauldron for Heating
Brooks Cables



H shows the Mercury Cup
LC Lamp Circuit SC Supply Circuit.

Fig. 1.



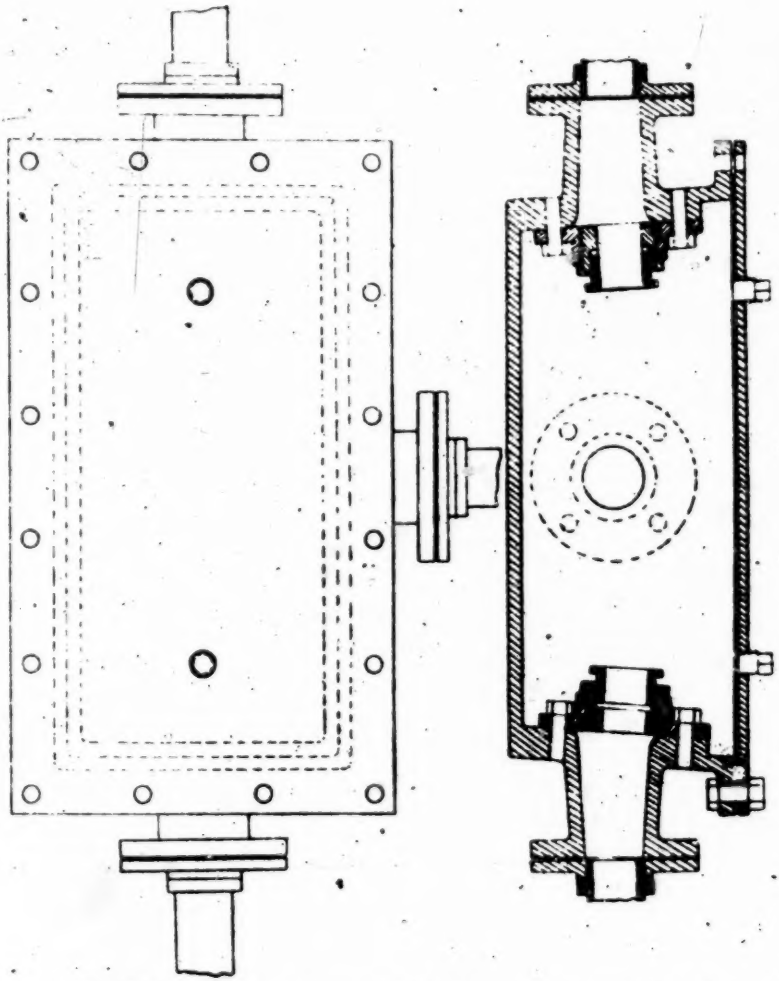


Fig. 7. Junction Box, Brook's System Plan and Section.

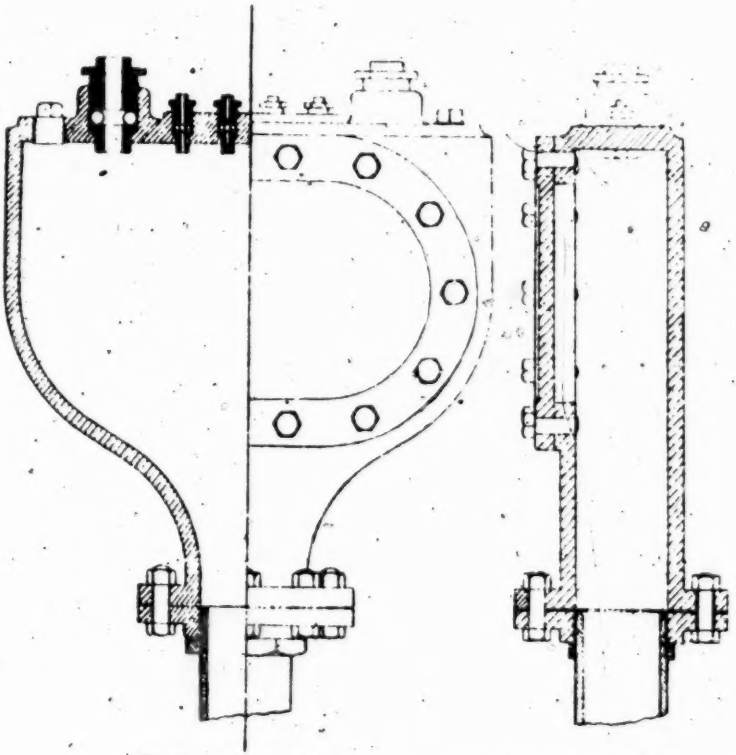


Fig. 8. Terminal Box, Elevation and Section

Plate 44

European System

Fig. 9 Brooks System at Hong Kong
Overhead and Underground

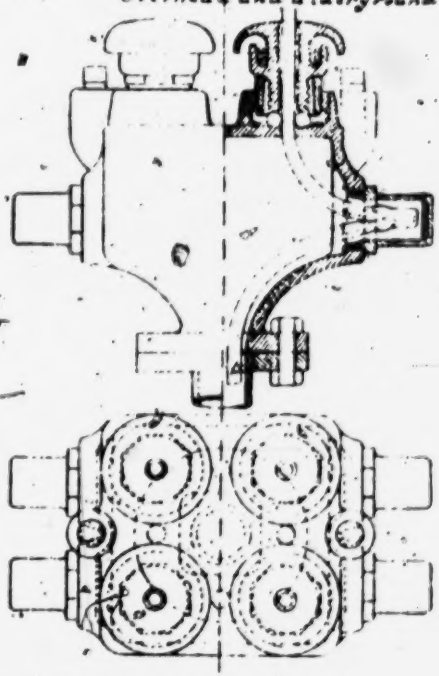


Fig. 10. Detail of Oil Insulator on Lamp Posts. Hong Kong.

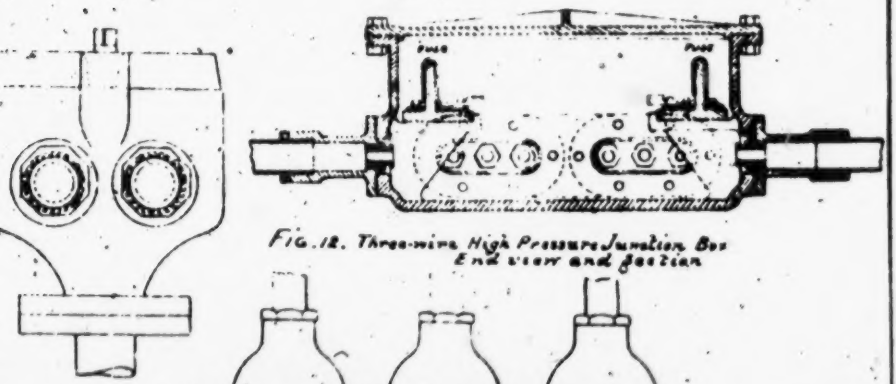


FIG. 12. Three-wire High Pressure Junction Box
End view and section

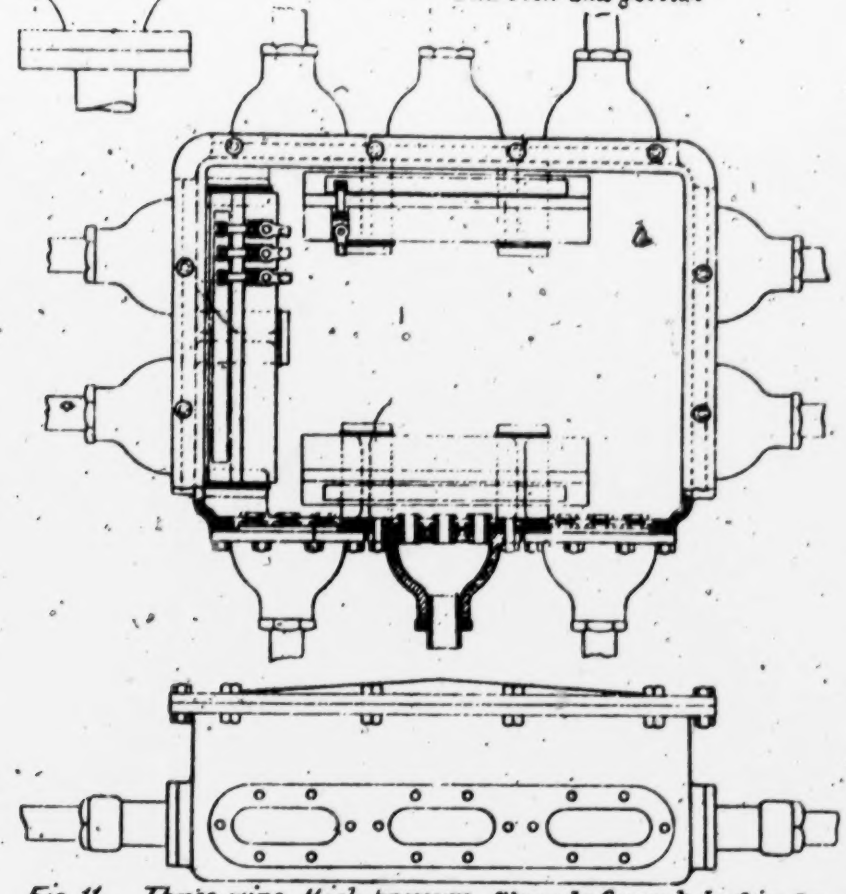


Fig. 11. Three-wire High-pressure Alternate Current Junction Box
Plan and side Elevation

N° 11,280 A.D. 1894

Date of Application, 11th June, 1894
Complete Specification Left, 6th Nov., 1894—Accepted, 8th Dec., 1894

PROVISIONAL SPECIFICATION.

Improvements in Jointing Electric Conductors.

WILLIAM GEIPEL, 49, Kidbrook Park Road, Blackheath, Kent, Electrical Engineer do hereby declare the nature of this invention to be as follows :—

My invention has reference to improved methods of jointing electric conductors whereby the joints are more easily made or disconnected for repair, testing, or otherwise, and whereby the insulation of the joint is more easily effected.

The invention refers to joints which are contained in boxes made of metal, wood, pot, or otherwise, the main use of the joint being for concentric conductors which are generally speaking more difficult to joint than separate conductors. At the same time I may use the box for separate conductors or partly for jointing concentric and separate conductors together. In order to accomplish this I bring the concentric conductors into the side of the box through glands or bushes. The outer strands of the conductor being clamped to a metallic connector within the box. The inner conductors are then slightly bent up and bared at the ends of the inner strands or covers and are then clamped to the inner connector. Two or more conductors may be thus jointed. After the joint is thus made the box may be filled with a suitable insulating material, as for example oil, wax, bitumen or by a combination of any of these according to the nature of the insulation used for the conductor itself. For example, with a vulcanised or pure rubber insulated conductor oil would be unsuitable as it dissolves rubber, therefore I should prefer to use wax or other material. With paper or jute insulated conductors oil may be used.

I bend up the inner conductor sufficiently to raise the inner connector above the level of the outer so that any of the inner conductors may be readily disconnected without removing the insulation of the outer conductors. I place more importance on being able to disconnect for testing or repair the inner conductor, as it is more necessary to insulate this throughout than the outer conductor which generally works at or about the potential of the earth, the inner generally being different in potential to the earth.

In some cases I do not cover the inner connector merely covering the outer with the insulating material in this event in order to prevent surface leakage across the top of the insulating material I may place a guard of wood or pot or other suitable substance which breaks the surface and increases the distance across which leakage may occur.

The cover of the box may be of the usual type many of which are in use at present. It may be either put on loosely, with or without an oil groove. Or the cover may be bolted to the box with or without packing of jute, lead or other material.

In the case of separate conductors I prefer to keep always those conductors which are at the same potential connected to the upper or lower connector as the case may be.

It is often advantageous to be able to joint conductors insulated with rubber to others insulated with paper, jute, hemp, flax, cotton or other suitable insulating material, the joints of which are best surrounded by oil.

In order to keep the rubber from the oil I bring the rubber-insulated conductors in at the top of the box, the ends being bared where they enter the oil; and, where it is necessary to support the rubber-insulated conductors, I arrange so that there

[Price 8d.]

are preferably several inches between the surface of the oil & the support, in order to improve the insulation of the joints.

Dated this 9th day of June 1894.

W. GEIPEL.

COMPLETE SPECIFICATION.

Improvements in Jointing Electric Conductors.

WILLIAM GEIPEL, 49, Kidbrook Park Road, Blackheath, Kent, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement :—

My invention has reference to improved methods of jointing electric conductors whereby the joints are more easily made or disconnected for repair, testing, or otherwise, and whereby the insulation of the joint is more easily effected.

My invention refers to joints which are contained in boxes made of metal, wood, pot, or otherwise, the main use of the joint being for concentric conductors which are generally speaking more difficult to joint than separate conductors At the same time I may use the box for separate conductors or for jointing concentric and separate conductors together. In order to accomplish this I bring the concentric conductors into the side of the box through glands or bushes. The outer strands of the conductor being clamped to a metallic connector within the box. The inner conductors are slightly bent up and bared at the ends of the inner strands or core and are then clamped to the inner connector. Two or more conductors may be thus jointed. After the joint is thus made the box may be filled with a suitable insulating material, as for example, oil, wax, bitumen, or by a combination of any of these according to the nature of the insulation used for the conductor itself. For example, with a vulcanised or pure rubber insulated conductor, oil would be unsuitable as it dissolves rubber, therefore I should prefer to use wax or other material. With paper or jute insulated conductors oil may be used.

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In some cases I do not cover the inner conductor, merely covering the outer with the insulating material, in this event in order to prevent surface leakage across the top of the insulating material I may place a guard of wood or pot or other suitable non-conducting substance which breaks the surface and increases the distance across which leakage may occur.

The cover of the box may be of the usual type, many of which are in use at present. It may be either put on loosely with or without an oil groove, or the cover may be bolted to the box with or without packing of jute, lead or other material.

Referring to the accompanying drawings, Fig. 1 is a plan and Figs. 2 and 3, are sectional elevations of the joint.

a is the box which contains the joint, *b*, *b*, are the glands or bushes in the sides of the box through which the conductors pass; *c*, *c*, are the clamps which connect together the outer conductors to the metallic connector *d*; *e*, *e*, are the inner conductors which are bent up and whose bared ends are clamped to the raised inner metallic connector *f*; *g* is the insulating material which is filled in after the joint is made. In the drawing *g* is shewn not covering the inner connector *f*, but merely covering the outer connector *e*, *d*, together with the insulating material which

surrounds the inner conductor *e*. *h* is the guard of non-conducting substance which reduces leakage across the surface of the insulating material *g*; should there be any tendency for leakage to take place between the inner connector and the box, as might be the case if dampness *etc.* existed. *i* is the cover of the box.

The illustrations shew a joint arranged for 3 concentric conductors but I may use it for jointing 2 or 4, or more by multiplying the glands and clamps.

In the case of separate conductors I prefer to keep always those conductors which are at the same potential connected to the upper connector *f* or lower connector *d* as the case may be, throughout the system. With separate conductors I arrange of course double the number of glands required for concentrics.

It is often advantageous to be able to joint conductors insulated with rubber to others insulated with paper, jute, hemp, flax, cotton or other suitable insulating material, the joints of which are best surrounded by oil.

Fig. 4 shews such an arrangement in plan, while Figs. 5 and 6 are sectional elevations of the same.

In order to keep the rubber from the oil I bring the rubber insulated conductors in at the top of the box, the ends being bared when they enter the oil; and, where it is necessary to support the rubber insulated conductors, I arrange so that there are preferably several inches between the surface of the oil and the supports, in order to improve the insulation of the joints.

Referring to Figs. 4, 5 & 6, *k* are the rubber insulated conductors, *l* being the bared ends which enter the oil; these ends may be either the ends of the conductors or they may be separate ends soldered or otherwise attached to the said conductors. In any case the ends are preferably smooth and bright so as to reduce creeping of the oil (if used) by capillary attraction. *m* is the support for the rubber covered conductors and in this case it is shewn combined with the cover of the box, the conductors being taken in through glands *n* so as to exclude moisture.

In the case of lead covered conductors I may attach the lead to the gland by means of a plumber's wiped joint, the gland being made oil tight with packing in the usual way. For india rubber covered concentric conductors, the glands may be made of wood or other suitable material.

In any of the above joints I may use a drying agent, such as calcium chloride to absorb any moisture which might be admitted.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, I declare that what I claim is:—

In electric joint boxes for concentric conductors, in which an insulating material, such as oil, wax, ozokerite *etc.* is used for protecting and insulating the joints, the improved arrangement whereby the conductors are brought in at the sides of the box in an approximately horizontal direction while the ends of the inner conductor are bent up so that the inner joints are made at a higher level than the outer joints, which consequently facilitates getting at the inner joints for repair, testing or otherwise, substantially as above described and set forth.

In electric joint boxes for separate conductors in which an insulating material such as oil, wax, ozokerite *etc.* is used for protecting and insulating the joints, the improved arrangements above described & set forth whereby the conductors are brought in at the sides of the box in an approximately horizontal direction, while the ends of one of the conductors, which is preferably always of the same polarity throughout the system, are bent up so that the joints on the said conductors are made at a higher level than those on the conductors of opposite polarity, which consequently facilitates getting at the said conductors for repair or otherwise as set forth.

In electric joint boxes for jointing india rubber covered conductors to conductors insulated with other materials than rubber in which an insulating material such as oil is used for protecting and insulating the joints, the improved arrangements

above described and set forth whereby the conductors with rubber covering may be brought in at the top of the box while the other aforesaid conductors may be brought in at the sides of the box in an approximately horizontal direction, the arrangement being such that the oil, while being used to improve the insulation of the conductors not insulated with rubber, is prevented from attacking and damaging the insulation of the rubber covered conductors.

Dated this 5th day of November 1894.

W. GEIPEL.

London: Printed for Her Majesty's Stationery Office, by Darling & Son, Ltd.,—1894

A.D. 1894 JUNE 11. N° 11,260.

GEIPEL'S COMPLETE SPECIFICATION.

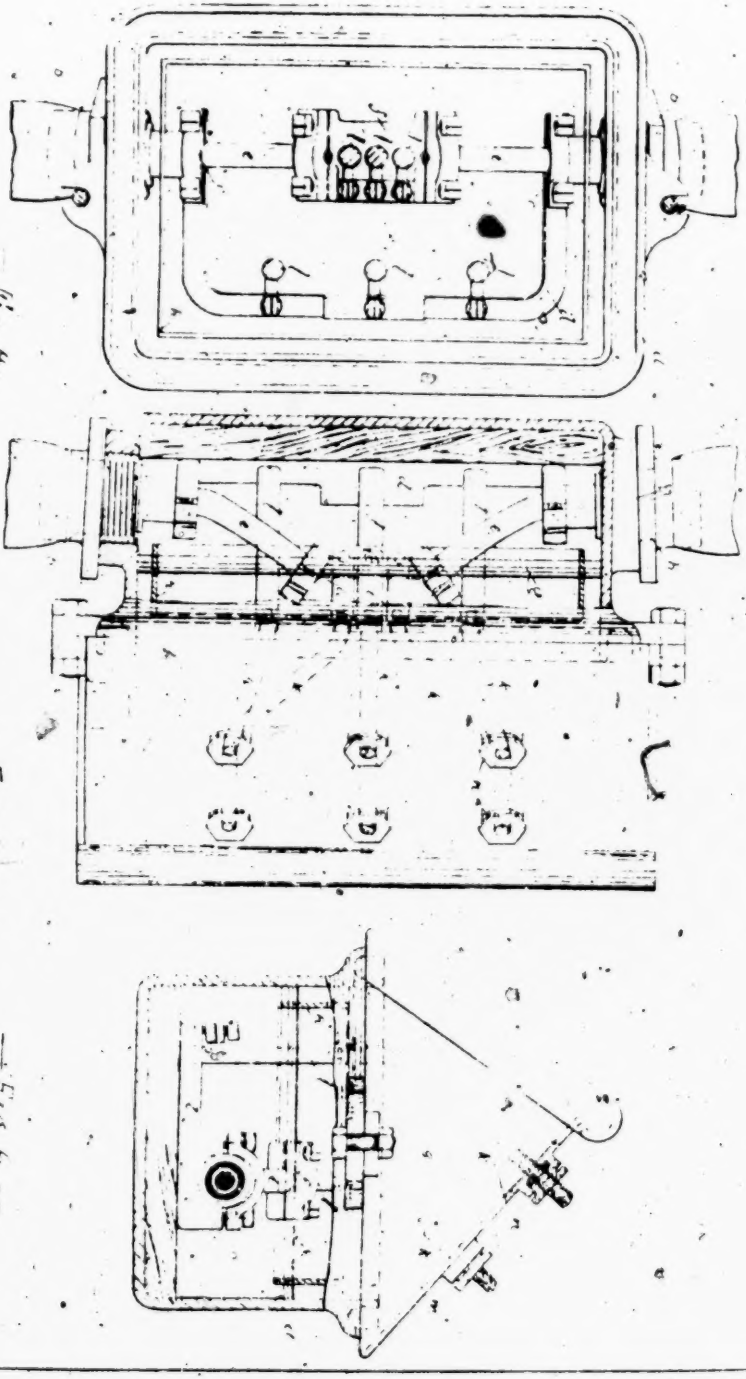
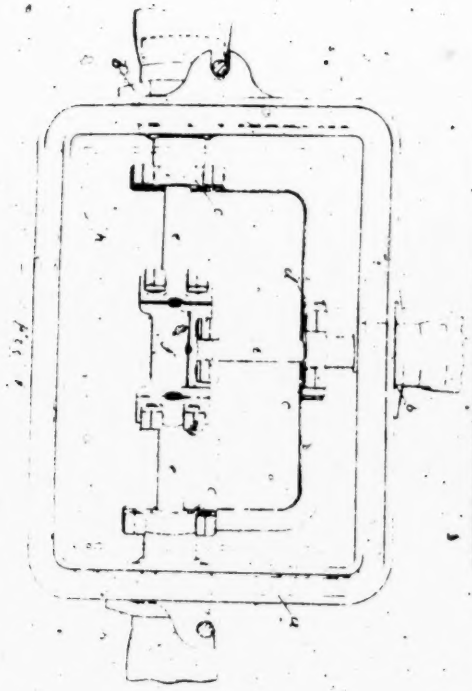


Fig 1.

Fig 2.

Fig 3.

London: Printed by
Her Majesty's Stn



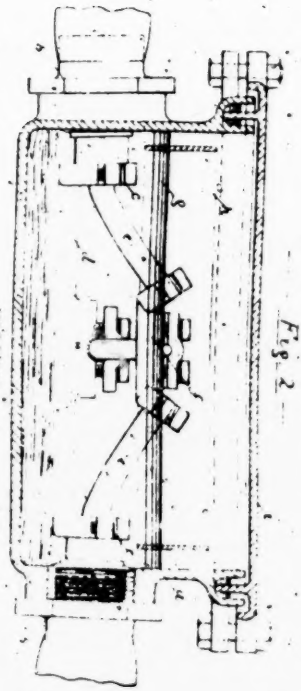
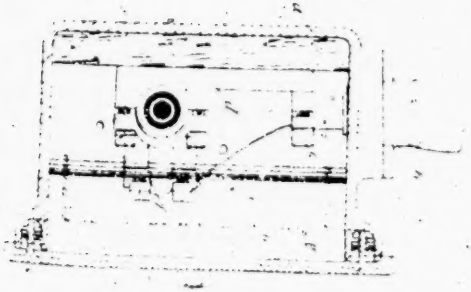


Fig. 2.



[This Drawing is a reproduction of the Original on a reduced scale.]

534,802. ELECTRIC METAL-WORKING APPARATUS. Hermann Lemp, Lynn, Mass., assignor to the Thomson Electric Welding Company, of Maine. Filed Dec. 3, 1892. Serial No. 453,918. (No model.)

To all whom it may concern:

Be it known that I, HERMANN LEMP, a citizen of the United States, and a resident of Lynn, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Electric Metal-Working Apparatus, of which the following is a specification.

My invention relates to transformers or converters and is designed especially to provide an efficient and cheap construction of a transformer adapted to furnish the heavy currents employed in electric welding and other metal working apparatus.

While I have described the invention as carried out in a transformer having its coil or conductor of heavy cross section forming the secondary thereof, it will be obvious to electricians that the transformer constructed as hereinafter described might be employed for generating currents of higher potential than those supplied to it by simply using the conductor of heavy cross section as a primary and, therefore, my claims are to be understood as covering that use of the construction specified in such claims which would involve simply the inversion of the apparatus, that part of the same which is for ordinary use the secondary becoming in such case the primary. I shall, however, describe the invention as carried out in a transformer wherein the conductor or coil of heavy cross section is used as a secondary to generate heavy currents.

My invention provides a transformer wherein magnetic leakage between the primary and secondary will be prevented; the primary will be protected from contact with the secondary in an effective manner while the primary will be rendered waterproof and shielded from mechanical injury as well; and the heat generated either in the primary or secondary during use will be readily carried away without breaking down the insulation.

The invention consists in making the secondary or heavy section element of the apparatus as a liquid tight tube which envelopes the primary and in keeping the primary immersed in oil contained in said secondary.

The invention consists further of an electric transformer having a primary wound with a number of turns and a secondary having but one turn and composed of a single tube which follows the winding of the primary coil and forms a tubular envelope or jacket therefor throughout substantially its whole length.

The invention consists further in making the secondary or heavy section element from two solid copper castings bolted together to form a tube inclosing the primary.

The invention consists also in the features of construction and combinations more particularly specified in the claims.

In the accompanying drawings:—Figure 1, illustrates a transformer embodying my invention the usual iron core being removed. Fig. 2 is a vertical longitudinal section of the transformer. Fig. 3, is a vertical cross section through said transformer on the line x, x, Fig. 2.

A, is the tubular secondary which contains the two primary fine wire coils F. The secondary or heavy section conductor A, is formed as a liquid tight tube and completely incloses the primary as shown.

The electrical terminals or poles of the secondary A, are formed at 5, where the ends of the tubular secondary come close together, the general shape in outline of the secondary being square or rectangular although this form may obviously be departed from to any desired extent. The secondary as will be seen forms but a single turn of very heavy cross section.

At or near the poles or terminals 5, 5, are mounted suitable contacts 6, 6, by which current may be taken off from the secondary for any desired purpose. These contacts 6, 6, are preferably formed as hemispherical blocks of copper accurately ground into sockets on the secondary.

To form an endless tube which may serve as a liquid receptacle containing the oil and primary the ends of the secondary are united at 5, by an insulating liquid tight joint 7, of any suitable character. This joint may be a piece of wood or any other suitable material and may be rendered absolutely tight by any well known cement poured between the metal and wood.

As will be seen from the drawings the secondary or heavy section conductor A, consists of two metal channel castings, fastened together by bolts at points 9. To form a good joint between the two halves of the secondary when thus bolted together a thin packing may be interposed between the halves at the joint. I do not limit myself to the exact form of the castings and they might, if desired, be of different shape in cross section if they both be adapted to form a tube when bolted together around the primary.

It will be understood that the primary is applied in the groove or channel of one of the castings and then the other placed over it to inclose it. The primary may consist of any form of conductor but preferably is made of copper strips insulated by asbestos, preferably asbestos cloth, and loosely wound to allow the asbestos to take up the oil and to permit a partial circulation of oil therethrough. The primary is held in position in the tube out of contact with the latter by means of supports or distance pieces 10, distributed at proper points. Terminals of the primary wire are indicated at 12. They pass through insulating bushings 13, in the casting A, which bushings are properly constructed to form a liquid tight joint. When the secondary has been placed around the primary and the proper liquid tight joints formed, as described, it is filled with oil, connection with a reservoir or supply pipe being maintained to allow for expansion under increase of temperature. Preferably I employ some heavy cylinder oil that shall stand as high a temperature as 100° centigrade. The oil affords waterproof insulation and a means for conveying heat away from the primary.

As shown the primary coil consists of a number of turns designed to produce from a current of considerable tension a current of reduced potential but very large volume in the secondary A. The oil may be introduced through an orifice at 14 or any other point. H, is a tube connected to such orifice and leading from any suitable reservoir J. The tube H, may be a flexible copper tube and the reservoir or stand pipe may be located at some distance from the transformer.

While it is preferable to make the secondary or heavy section element as an endless tube by joining its ends through an insulating joint, it will be obvious that my invention is not limited to such construction as the ends might be at some distance from one another and the two free ends of the tube stopped independently of one another. I prefer, however, to use the construction shown wherein the tube is made endless, by bringing the terminals of the casting in close proximity and joining them through an insulated joint. K is the usual laminated iron core made in two or more sections secured together and threading the primary and secondary as indicated at K.

In this transformer it will be seen that the maximum efficiency is obtained for a given weight of copper inasmuch as the secondary completely surrounds the primary coil so that the lines of force generated by the primary shall cut the secondary to the greatest extent possible.

What I claim as my invention is—

1. An induction coil or converter having a secondary constituting a liquid tight tube enveloping the primary and containing oil, as and for the purpose described.

2. In an induction coil or converter, the combination with the primary, of a tube enveloping the same and constituting the secondary, said tube having its ends united by an insulating liquid tight joint to form a liquid receptacle, and containing oil, as and for the purpose described.

3. The combination in a converter, of a primary having a number of turns and a secondary consisting of a sealed metal tube enveloping the primary coil and containing oil, and for the purpose described.

4. An electric transformer having a primary wound with a number of turns and a secondary having but one turn and composed of a single tube which follows the winding of the primary coil and forms a tubular envelope or

732

jacket therefor throughout substantially its whole length.

5. In an electric transformer, the combination with a primary having a number of turns, of a secondary having but a single turn enveloping the primary coil, and filled with oil, substantially as described.

6. In a transformer, a secondary consisting of two metal channel castings fastened together to form a tube, in combination with a primary contained in said tube.

7. In a transformer, a secondary having a single turn composed of two grooved castings secured together to form a tube containing the primary.

8. In a transformer, the combination with a tubular secondary forming an oil containing receptacle, of a primary enveloped thereby, and consisting of loosely wound metal strips separated by asbestos.

9. In a converter, the combination with a tubular secondary, of an inclosed loosely wound primary immersed in oil contained in said secondary, as and for the purpose described.

10. In a converter, the combination with the primary, of a secondary consisting of two solid copper castings bolted together so as to form a tube inclosing the primary, the interior space being filled with oil, as and for the purpose described.

11. The combination, substantially as described, in a transformer, of a tubular secondary inclosing the primary and filled with oil, and an oil reservoir or stand pipe connected with said tubular secondary, as and for the purpose described.

12. The combination, substantially as described, with the tubular secondary, of a primary supported out of contact with the tube by suitable distance pieces or supports and immersed in oil cointained in said secondary, as and for the purpose described.

Signed at Lynn, in the county of Essex and State of Massachusetts, this 30th day of November, A. D. 1892.

HERMANN LEMP.

Witnesses:
F. P. MOONEY,
A. R. EVEREST.

No. Model.

H. LEMP.

ELECTRIC METAL WORKING APPARATUS.

No. 534,302. Patented Feb. 26, 1895.

FIG. 1.

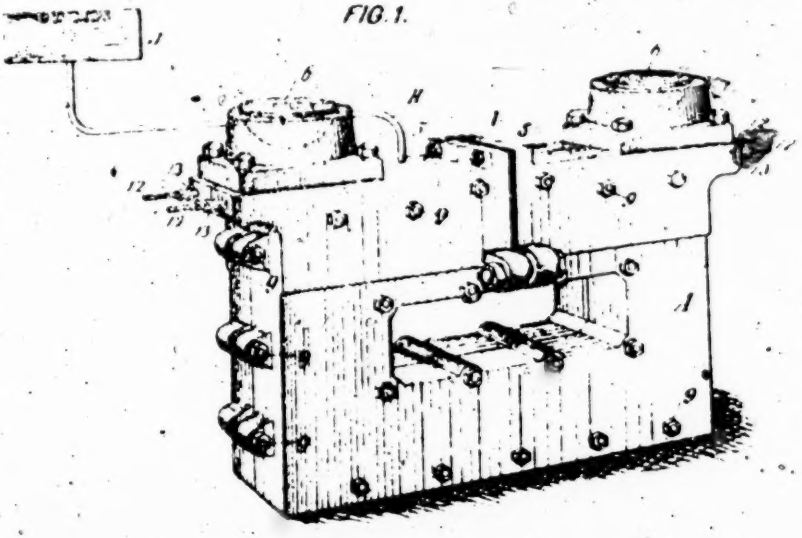


FIG. 3.

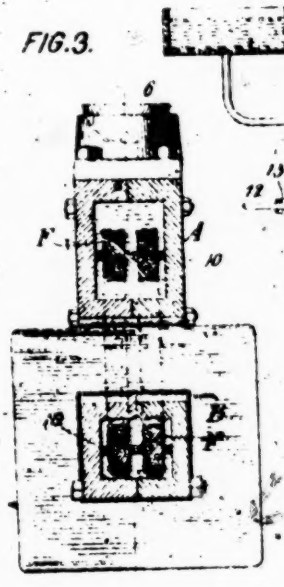
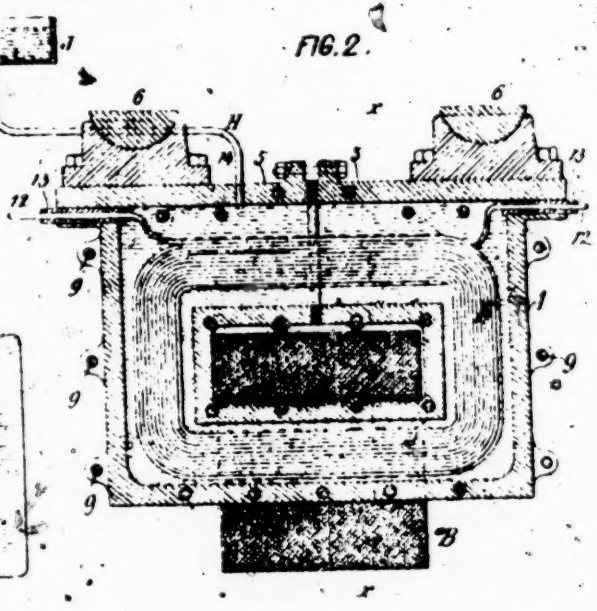


FIG. 2.



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29 WEST THIRTY-NINTH STREET, NEW YORK
CABLE ADDRESS: ENGINEERS

Translation

(Title Page)

The Calculation, the Construction, and the Operation of the Cable System of the Municipality of Amsterdam.

Thesis written to obtain the degree of Doctor in Technical Science at the Engineering Academy of Delft.

On the authority of the Dean
Dr. S. Hoogewerff, Professor in the Department of Technology and Mining,
to be defended before the Senate, on Thursday, June 20, 1907, at 2.30 p.m. by

Gerard de Gelder, mechanical and electrical engineer, Engineer of the Municipal Electricity Works of Amsterdam, born at Batavia.

Printed by F.J. Belinfante, successor to A.D. Schinkel, The Hague.

- 1907 -

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(Last two paragraphs of Introduction on page XII)

The purpose of this dissertation is to give a complete, but concise picture of the development of the cable system, from the first calculations to the complete operating conditions.

As has already been observed, the cable system of the Municipality of Amsterdam also includes the direct current cables feeding the overhead net of the street-car system. In the following, however, the main subject will be the cable system for light and power, in other words the three-phase cable net. Only in the discussion of the heating of cables, is mention made in a few words of direct current cables.

(Page 55, line 9, to end of Section 12, page 57)

Then the impregnated paper is investigated; the impregnating mass should not be too soft or too thinly liquid, and certainly not too resinous; when bent back and forth, the insulated conductor should not produce any creaking sound.

After impregnation, the ultimate strength should be at least 25 per cent higher.

The following may be said in regard to the winding of the cores with paper strips. The layers of paper should be laid one over the other with a certain overlap, and not - as erroneously stated by Dr. Baur in his book - with their edges abutting. In the latter case the insulation would be thinner by one layer of paper. This overlap must be at least 3 mm. Also, there should be specified the pitch with which the layers of paper should be wound around the conductors. This pitch should not be too steep, as else there is danger of tearing.

For thick cables, a pitch of 20 mm should be specified, and for thinner

cables, a pitch of 10 mm.

Finally, it is necessary also to specify the thickness of the insulation. Many cable engineers believe that this should be left to the cable manufacturer, as the latter actually must guarantee the dielectric strength. We consider this too dangerous, as in many cases strong competition compels the cable manufacturers to adopt extreme limits, not so much in order to save insulation material, but to save lead by reducing the inside diameter of the lead sheath. A minimum requirement is therefore desirable, and we would suggest the following values in this respect, for three-phase cables for 3000 volts:

	High tension cables for 3000 volts			
Cross section area in sq. mm	3 × 95	3 × 50	3 × 25	3 × 10
Minimum number of layers of paper	11	11	10	10
Minimum thickness of insulation on each conductor	1.9	1.9	1.75	1.75
Minimum total thickness of insulation	3.8	3.8	3.50	3.50

Moreover, it should be specified that the maximum of each paper strip, in the unimpregnated condition, should be 0.15 mm, and 0.17 mm in the impregnated condition.

For low tension cables up to 500 volts, a minimum thickness of insulation of 1 mm around each conductor should be specified, and furthermore, a minimum increase in the thicknesses of the insulation of 0.15 mm for each additional 500 volts; thicker copper conductors are given a thickness of insulation that is even somewhat greater.

We repeat with emphasis that the above values represent the minimum thicknesses and apply only to pure manila paper with a not too thick impreg-

nating mass, and, of course, without any filling of jute or other fibrous materials.

The IMPREGNATION of the paper insulation should take place with a rather thin liquid, oily, and a not too resinous mass. It may be true that a dry, resinous mass gives a higher insulation resistance when measured, but it is much less resistive against breakdown. Moreover, the drier the impregnating mass, the more hygroscopic it is, and the sooner the cable will absorb moisture. These are two disadvantages, therefore, to be cited against a too dry mass. This is why it is incorrect to require a high insulation resistance for the cables. Such resistance is easily obtained by adding to the cable mass a larger quantity of solid resinous substances, a measure which does not increase the cost. It is also incorrect to ascribe as for insulation resistance in all cases to poor boiling and impregnating of the insulation exclusively. We shall refer to this question again later.

(Section 18, pages 74 to 80.

Section 18. The assembling of the cables.

The first point to be discussed here is the manufacture of the joints or solid connections of the cables. Where lead cables are concerned, cast iron junction boxes are used for this purpose in most cases. The cable joints should always be considered weak spots in the cable system. In fact this is evident, as the junction boxes are foreign bodies in the cable system; they differ in every respect from the cable, both in weight and construction. The greater weight may be the cause of the cables showing a tendency to sag in the vicinity of the junction boxes; the discontinuity of the copper conductors reduces the strength of the cable; the interruption of the lead sheath forms a vulnerable spot for the infiltration of water and electrolysis.

In Amsterdam the sagging of a junction box is counteracted by providing, below the box, a wide slab of cement in order to increase the supporting area. Sagging in other parts of the cable may be the cause of a very great pull being exerted on the cable - as discussed in the first chapter - as a result of which the conductors, which are spread out in the box are pulled toward each other so that the bare parts are liable to touch each other, in which case short-circuiting will result. Ultimately, it is even possible that the connections may be pulled completely apart. All this should be prevented, in the first place, by providing the junction box with wide clamps that exert a firm grip on the steel sheath of the cable. The manufacturers often have the habit of making a junction box intended for different cables with one bore suitable for the thickest cable for which that particular junction box can be used. Thin cables, when introduced, are wound with asphalt tape in order to obtain the thickness required. This should be avoided, as the asphalt tape shifts too easily, and the pull is then transmitted to the copper conductors.

Even with the best method of clamping, part of the pull will always be transmitted to the copper conductors, and the connection of the ends of the latter therefore must be very substantial. The exclusive use of small cable sockets (that is, the copper connecting bushings) with set screws, is insufficient, although assembling is quickest in this manner. In our opinion, it is absolutely necessary to make the connection by soldering also and, therefore, to provide the properly tinned copper cable socket not only with set screws, but also with an oval hole in the center for the purpose of soldering. The oval hole also makes it possible to see clearly whether the ends of the copper conductors meet; the connection obtained by means of

soldering and set screws is the strongest one imaginable.

The infiltration of water and moisture can be prevented by proper construction of the cast iron junction box. Experience has shown that the water penetrates from the outside, along the steel sheath, over the lead sheath, into the interior; this takes place more easily as the lead sheath, of course, does not completely close the admission hole. For this reason, it is necessary to provide an additional space between the cable clamp and the admission hole for the lead sheath, and to fill this with asphalt. This space, called the "asphalt chamber", is lacking in the junction boxes of many firms; however, it is indispensable.

The seal for the two halves of the cast iron junction box is made by providing a groove along the entire edge of the box, this groove being tightly tamped with tarred hemp and then filled with asphalt. This groove has still another purpose. In fact, if the lead sheath should be the conductor of earth currents (stray currents), the latter will easily pass to the cast iron junction box at the spot where the lead sheath is interrupted[1]. The spot where this transfer occurs is also a spot where the lead sheath will deteriorate; it is here that corrosion takes place. For this reason, the two ends of the lead sheath are connected together, in Amsterdam, by means of 4 copper wires with a cross-sectional area of at least 2.5 sq.mm. These copper wires are properly soldered to the lead sheath, and then introduced in pairs into the grooves referred to above, where they are protected by the asphalt at the same time.

After the copper connections have been made, the junction box is closed

1. See also C. Feldmann and J. Herzog, E.T.Z., 1906.

and completely filled with the hot mass. Before this is done, the two halves are thoroughly preheated to prevent the mass from cooling too much when it is poured in. The mass must be thoroughly heated and thinly liquid, in order to penetrate everywhere. Thereupon, one waits quietly until the junction box has cooled sufficiently and the box then is given a supplementary filling, so that when cooled, no empty space is left in it. The rest of the mass is poured over the nuts, bolts and plugs, in order better to protect these parts against rust.

Finally, there should be recommended the exclusive use of substantial, amply designed junction boxes. Too narrow boxes cause the cable ends to come too close together. A slight pull in the cables is then sufficient to cause short-circuiting. An insulation defect of this kind is often very difficult to find. A very small contact is sufficient to cause the fuses to function; after the cable has cooled, the contact points recede from each other a fraction of a millimeter, and the mass, which has melted locally, re-establishes the insulation. When making measurements, one generally finds good insulation resistance, which is too great to locate the defect by measurement of errors, so that the detection requires much trouble and expense. This does not prevent many manufacturers from making the junction boxes as small as possible, not only to save on iron, but principally to save on filling mass, which indeed is very expensive.

However, a warning should be issued not to yield too much to this desire of making savings.

In addition to the cast iron junction boxes referred to above, which are commonly used on the Continent, still another type of connection has been adopted in Amsterdam, designated by us as the lead socket, or the

British connection socket. As this socket is still relatively little known but has given excellent results, we believe it is also necessary to describe this method of connecting in detail. With this connecting socket, the lead sheath is continuous and the socket is almost of the same weight and the same composition as the cable itself. In general, this socket is used for high tension cables exclusively, in Amsterdam.

The two cable ends are carefully freed from the steel sheath, the lead sheath, and the insulation for a specified length; no more is cut off from the insulation than is absolutely necessary. Then, a cylindrical tube, cast in one piece, with a length of about 40 cm, is shoved over one of the cable ends, and the process of connecting the copper conductors is started. As a rule, this is not done by small copper connecting sockets, but in the old-fashioned manner. The outer wires of one of the copper conductors, and the inner wires of the other, are cut off, and the two halves, carefully aligned and cleaned, are shoved together, tightly wound with thin copper wire, and then carefully soldered. If all this is properly done and carried out by a competent mechanic, the joint is not thicker than the copper conductor itself, while the copper resistance has not become lower, and the strength greater. Subsequently, the joined conductors are wound with linen tape, with a certain overlap. This linen tape is first boiled, in form of small rolls, in hot oil for at least one hour, so that it is completely saturated with oil and free from moisture. After the first layer has been applied, mica is interposed between all subsequent layers, this mica consisting of thin sheets which can easily adapt themselves to the winding process. For 3000 volts, eight layers of linen tape are used, between which there are consequently 6 layers of mica. In this way, an excellent insulation is obtained.

Thereupon, the insulated conductors are pressed against each other and a common insulation, also consisting of 8 layers of tape and 6 layers of mica, is arranged around each group of three conductors. This completes the insulating job and the entire joint has a thickness which, at most, is twice as great as that inside the lead sheath of the cable itself.

Finally, the difficult job of soldering the lead socket must be done. The lead cylinder is pushed up until it is just above the joint: then, the ends are beaten down until they fit exactly on the lead sheath which first has been made bright by sandpapering. The lead cylinder is covered with a mixture of soot; only the ends are left bright. The soldering is done as follows: The mechanic has the pot of lead nearby, this containing the molten mixture of lead solder. He does everything with two iron spoons and a piece of chamois.

He holds one of the spoons under the lead sheath, and "showers", as it were, the joint with the other spoon, repeating this with the lower spoon, etc. All the time, he wipes off the joint with his piece of chamois, in order to prevent the thickness from becoming excessive. The joint finally acquires a proper shape; it should be entirely smooth, without irregularities. The two connected ends of the lead socket are called the "knot". The making of the "knot" is an extremely difficult job. It may easily happen that a hole is burned in the lead sheath, with consequent damage to the insulation. Also, it may happen that because of the rubbing the lead sheath becomes too thin locally, or unnecessary thicknesses and bumps may be formed. An otherwise well-trained mechanic still requires some months for learning this soldering process. No wonder: lead soldering in itself is known to be especially difficult, and this job is most difficult of all, particularly

as it is necessary to work all the time at the limit of the melting point of the lead, not even an excess in temperature of ten degrees being permissible.

After the soldering of the lead socket has been completed, a small square hole is cut in the top of the lead socket, and hot insulation mass is poured into the socket. For this purpose, the same mass, or rather the same oil, is used as for impregnating the cable. It is a kind of resin oil. After the socket has been filled, the hole is closed again by soldering.

A disadvantage of this type of connection is that the socket requires additional mechanical protection. For this, we use a second socket or junction box made of cast iron in which the sheathing is tightly clamped and which is completely filled with asphalt. Thus, all requirements of a good junction box are met. The lead sheathing is continuous so that no water can infiltrate. The insulation is as good as that of the cables and there are no parts within the socket that are not insulated.

A second drawback is also that the manufacture of the British socket connection takes much time. A mechanic can make two normal (German) connections as against one British one. The insulation, and the logical design throughout, however, is considered by us to be so great an advantage as to make us decidedly prefer the British socket for high tension cables.

The accompanying illustration, Fig. 21, gives a clear picture of the construction. Two copper conductors of a phase are shown ready to be connected; the next phase has already been connected but not yet insulated; and a third phase has been insulated, while the beginning of the common insulation (especially made for this purpose) is also shown. It also shows how the copper sheath, which is placed underneath the lead sheath, is con-

nected by means of pieces of sheet copper. In the picture, the lead socket has already been soldered and then partly cut through. The two prepared ends, the flawlessly executed knots, are visible. The lower half of the cast iron junction box has also been put into place. The entire system is the test piece of a mechanic of the Municipal Electricity Works, which he must produce before being eligible for promotion.

The branching connections. The manufacture of the branching connections is carried out in exactly the same manner as that of the through connections. Due attention must be paid to the proper construction of the branching clamps in order to avoid the danger of contact in bridging over. The manufacture of branching connections in the British manner is also possible. In this case, however, the protecting cast iron box is excessively large and heavy. In Amsterdam, high tension branchings are therefore made in the usual manner, as with the German socket, that is, without a continuous lead socket. However, in doing this, all bright parts are wound with linen tape and mica, as in the case of the British connecting sockets. As a rule, however, one avoids making high-tension branch connections. In a large installation it is preferable to cut the cable, the two ends being introduced into the plant and connected together by means of a fuse. In this way, the necessity of making a branching connection is avoided and, moreover, the advantage is obtained of being able to provide the plant with current from two different sides. If branching is unavoidable, it is also possible to use a high tension cable box that can be switched out.

The cable boxes. An expert construction of cable boxes also is a primary requirement of a good cable system. If, for the sake of making work on the cable easier, and for reliability in operation, it is desired to sub-

divide the low tension net as much as possible, it is necessary to place a large number of cable boxes at all crossing points.

The conditions to be met by a cable box, are the following:

1. Ample construction of the box sockets. The box sockets, that is, the terminal pieces of the cables, must be at least equal to half a junction box, both as to construction and dimensions. In other words, they should have substantial clamps for gripping the cable; an asphalt chamber should not be lacking; etc.

2. Precise construction of the collecting bars. The construction of the collecting bars, especially, is a difficult problem requiring great care. In our cable boxes, the collecting bars are placed on large bell-shaped insulators, so that the infiltration of some water can not have any bad consequences. Moreover, porcelain has proved to be the only insulation suitable for this purpose, in our climate.

3. Proper sealing. The seal must be made by means of tightly fitting edges with rubber rings, and closing must take place by means of substantial nuts.

4. Uniformity of the length of the fuses. For the fuses, preferably silver, the same length must be adopted for the entire cable system.

(Page 60, at top)

Note by translator: Mentions asphalt-impregnated paper used for protecting the lead sheath.

(Page 94, lines 18 - 24)

The Amsterdam high tension cables are supplied by a British firm, and the other cables are from a German manufacturer. Both types of cables are paper cables, but the impregnating mass is a very different composition

In the British cables, it is a rather thin resinous oil at 15° C, while in the German cables, on the contrary it is a thicker mass.

(Pages 96, lines 12-14)

The curves show that the German cables which have dried out more intensively, have a considerably greater decrease than the British cables, in which a thin impregnating mass is used.

(Page 131, line 1[illegible], to bottom of page 132)

Permissible temperature of the cable

There are very many opinions on the question of what rise in temperature must be considered as detrimental, but most of these opinions, however, are based on very weak bases. These different opinions have all been collected and reproduced in the well-known book by Teichmüller* so that we need not refer to them again here. There are only a few points that we should like to discuss.

It was shown first by Herzog and Feldmann, and later confirmed by Apt and Mauritius, and others, that the danger of the breakdown of paper cables decreases rather than increases at higher temperatures, the reason being that the impregnating mass, which has become thinner, fills all of the pores better and penetrates everywhere. We have also already expressed the opinion, elsewhere, that a thinner mass gives a better guarantee against breakdown than the harder ones. Consequently it is also our opinion that the permissible rise in temperature is NOT determined by the danger of breakdown.

In our opinion, the flowing of the mass from the junction boxes, caused by too intense heating, is more dangerous. In fact, if the mass is pressed out because of too strong heating, it is highly probable that, when contraction

* Dr. Teichmüller. The heating of electric conduits, Stuttgart, 1905.

takes place, WATER will be sucked in, even though the junction box may be well sealed. It is true that for a certain time, a sufficient amount of mass will remain suspended around the copper conductors, but this mass, usually a mixture of rubber and resin, will spoil under the influence of water and therefore will cause a defect in the cable anyway. However, according to our observations the mass will not flow fromcorrectly assembled junction boxes, such as those used by the Municipal Electricity Works, until the temperature of the cable has become 90° C, which temperature doubtlessly will not be permitted to occur, for other reasons!

A more serious danger, in our opinion, is that of the downward shifting of the impregnating mass and the drying out of the cable. We may assume that a cable always will have a vertical section, either in transformer and cable booths, or in the central station. If the mass in these sections becomes too fluid, it will shift downward and will not rise again when cooling occurs. Therefore the cable ends dry out and no longer resist breakdown. In our opinion, the permissible temperature rise is determined, therefore, NOT by the temperature of the cables in the GROUND, but solely by the temperature of the FREE CABLE ENDS. In other words, the measurement of the temperature of the cables as laid in the ground is relatively valueless or, at least, of less importance than the measurement of the temperature of cables mounted in cable booths and in the central station. According to our observations, the mass begins to shift at a temperature as low as 50 to 60° C. Therefore we assume that 55° C is the maximum temperature that a paper cable should be allowed to reach. If furthermore, we assume that 30° C no doubt may be taken as the highest temperature occurring in the shade in our climate, then we find that the maximum temperature rise that a cable may undergo is:

$$t = 25° C$$

631
750

In determining the values of t, we therefore reach the same conclusion as several other observers, and which has been specified in the standards for direct current cables. However, our temperature rise t is to be determined, not for cables that have been laid in the ground, but for cables that are attached, above the ground, against a wall, or that are freely mounted.

I have read this entire thesis and found no reference in it to impregnating compounds other than those mentioned in the above translation.

John Gaillard

John Gaillard

N° 12,146 A.D. 1909

Date of Application, 22nd May, 1909

Complete Specification Left, 17th Nov., 1909—Accepted, 19th May, 1910

PROVISIONAL SPECIFICATION.

Improvements in and relating to Electrical Conductors.

I, CHARLES VERNIER, Electrical Engineer, of 32, Bath Terrace, Gosforth, Newcastle-on-Tyne, in the County of Northumberland, do hereby declare the nature of this invention to be as follows:—

The invention relates to electrical conductors and in particular to cables for transmitting electric current for power or lighting. Such cables are subjected to alterations in length due either to external changes of temperature, to internal changes due to variations in the current passing, or to subsidences of the ground and like mechanical causes.

Proposals have been made for devices and arrangements adapted to allow the cable to expand and contract to meet the changing conditions, but those in commercial use at present are either merely incomplete solutions of the problem inasmuch as the changes of dimensions are only partly provided for, or on the other hand the electrical continuity of the cable is seriously interfered with; thus for instance, in the case of concentric or multi-core cables, it is found that the individual conductors expand and contract independently of one another and of the external sheathing, so that the course sometimes adopted of snaking or waving the cable to provide a certain amount of slack, does not fully meet the conditions of the case.

Moreover; the usual sweated joint enclosed in a lead casing and buried in the ground has been found to give great trouble when the cables are loaded to an extent approaching their maximum capacity, notwithstanding the provision of expansion joints at intervals in the joint boxes.

A main object of the present invention is therefore to provide a simple form of expansion joint which may take the place of the present sweated joint while at the same time suitable for use with any type of joint box now in common use.

To these ends the present invention consists in an expansion joint for electrical cables or other conductors according to which the alignment of the cable is maintained by one or more sliding sleeves, guides or equivalent devices; while the joint is bridged by flexible connections preferably arranged substantially symmetrically about the cable axis, and disposed either around or within the aligning means.

The invention also consists in a joint as described, in which the aligning means is or are connected to the bridging connections, so as to maintain correctly the operative relationship of the aligning means and cable during expansion or contraction.

The invention still further consists in a joint as described in which appropriate surfaces of the cable or its adjuncts are arranged to butt against one another after a certain predetermined amount of contraction or expansion, so that any further changes in length may be transmitted to neighbouring couplings.

The invention finally consists in the improved joints for electrical conductors hereinafter described or indicated.

[Price 8d.]

In carrying the invention into effect according to one form, the adjoining ends of the cable to be coupled together are surrounded by a sleeve preferably tapered at the ends, and adapted to slide freely on the cables themselves. A certain distance back from the ends of the cables a number of lengths of flat copper braid are electrically connected to the cable by binding with wire. The lengths of copper braid are then passed across to the adjoining length of cable, so as to bridge the joint, preferably being given a certain amount of spiral lay, and their free ends are then bound in place as before. In order to ensure that the sleeve maintains its proper operative relationship to the ends of the cables, I may provide a circumferential groove at about the centre of its length, and bind the lengths of braid to the sleeve in the neighbourhood of the groove so that the sleeve always remains about midway between the bound ends of the copper braid.

The flexible bridging connections are preferably arranged symmetrically about the axis of the cable, both for mechanical reasons and also to provide the required cross-sectional area for the current.

It will be seen from the above description, and the form of the invention described in detail, that the essential features of the improved coupling consist in (*a*) a suitable device for maintaining the alignment of the adjoining lengths of cable, (*b*) an appropriate method of maintaining electrical continuity between the bridging connections and the cable lengths themselves, and (*c*) providing sufficient flexibility in the bridging connections themselves.

Each of these features may take different forms.

Thus, for instance, the aligning sleeve described, as internally disposed in relation to the bridging connections, may be sweated at one end if desired to the cable, or may be replaced by a device according to which flanges are secured to the cable ends, one such flange carrying a series of projecting rods or bars, while the other flange is provided with corresponding holes through which such rods pass. Such an arrangement is in many cases convenient, since a copper spiral can be disposed round each such rod and connected at its ends to the flanges.

As regards the second essential feature of the invention, namely, the maintenance of the electrical continuity between the bridging connections and cables, many modifications may also be made from that described above.

Thus, for instance, the tapes or braids disposed round the cable may be clamped in place by screw clamps or they may be held in place by a collar screwed on to a conical thread on the exterior of a split sleeve, while according to another modification flanges may be provided on the cable ends as before and the outwardly or inwardly bent ends of the bridging connections clamped to the face of these flanges by an appropriate ring screwed or otherwise fastened in place; or again the flexible connections may be soldered or sweated to the cables. In other cases connections of circular cross-section hammered flat at the ends may be employed.

Furthermore, the necessary flexibility of the bridging connections may likewise be varied from the forms described above.

In small cables for example, a single spiral coil will be sufficient to provide for the movement of the cables while at the same time giving sufficient area for the current.

In other cases however, the flexible bridging connections may take the form of a flexible woven metallic tube, or the tape or braid connections whether flat or round may be bent into various patterns.

In any of the forms of joint described or indicated above, I may so design the proportions of the coupling that after a certain amount of expansion, the ends of adjacent lengths of cable butt against one another, so that any further expansion is dealt with in neighbouring couplings, or on the other hand I may so modify the device that after a certain predetermined amount of contraction, appropriate surfaces for instance, on the flanges above described and

the enlarged ends of the guide rods passing therethrough, butt against one another and prevent further contraction, putting strain on the bridging connections themselves.

In any of the forms of my invention, a cable may be enclosed in a suitable box filled with oil or in a tube surrounding the coupling and plugged at the ends and itself disposed in a box filled with bitumen or other suitable composition; or again the coupling may be enclosed in one or more tubes of linen or canvas to prevent the compound or oil getting amongst the flexible connections.

Although I have specifically described examples only of single core cables, it will be evident that many of the forms of coupling above indicated can also be adapted to couple concentric cables, the innermost core being first dealt with and surrounded by suitable insulation and it may be also by a metal sleeve or the like on which to joint the next layer and so on.

I wish it to be understood that although I have described certain forms of my invention in detail, and indicated how such forms may be modified in certain respects, I nevertheless do not intend to restrict myself to such forms or modifications, as it will be evident that the essential features of the invention pointed out in the earlier part of the specification may be embodied in a great variety of different forms.

Dated this 22nd day of May, 1909.

MARKS & CLERK,
18, Southampton Buildings, London, W.C.,
13, Temple Street, Birmingham, and
30, Cross Street, Manchester,
Agents.

COMPLETE SPECIFICATION.

Improvements in and relating to Electrical Conductors.

I, CHARLES VERNIER, Electrical Engineer, of 32, Bath Terrace, Gosforth, Newcastle-on-Tyne, in the County of Northumberland, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to electrical conductors and in particular to cables for transmitting electric current for power or lighting. Such cables are subjected to alterations in length due either to external changes of temperature, to internal changes due to variations in the current passing, or to subsidence of the ground and like mechanical causes.

Proposals have been made for devices and arrangements adapted to allow the cable to expand and contract to meet the changing conditions, but those in commercial use at present are either merely incomplete solutions of the problem inasmuch as the changes of dimensions are only partly provided for, or on the other hand the electrical continuity of the cable is seriously interfered with; thus for instance, in the case of concentric or multi-core cables, it is found that the individual conductors expand and contract independently of one another and of the external sheathing, so that the course sometimes adopted of snaking or waving the cable to provide a certain amount of slack, does not fully meet the conditions of the case.

In particular, the usual sweated joint enclosed in an external joint box has been found to give great trouble when the cables are loaded to an extent

approaching their maximum capacity, owing to the lack of efficient means for providing for the expansion and contraction of the cable conductors.

A main object of the present invention is therefore to provide a simple form of expansion joint which may take the place of the present sweated joint while at the same time suitable for use with any type of joint box now in common use.

To these ends the present invention consists in an expansion joint for electrical cables or other conductors according to which the alignment of the cable is maintained by one or more sliding sleeves, or like guiding devices, co-acting directly with the conductors or flanges or the like integral therewith, while the joint is bridged by flexible connections preferably arranged substantially symmetrically about the cable axis, and disposed either around or within the aligning means.

The invention also consists in a joint as described in which the aligning means is or are connected to the bridging connections, so as to maintain correctly the operative relationship of the aligning means and cable during expansion or contraction.

The invention finally consists in the improved joints for electrical conductors hereinafter described or indicated.

Referring to the accompanying drawings which form part of the specification.

Figure 1 shows a side elevation of one form of joint with spiralled bridging connections.

Figure 2 being a corresponding longitudinal section and

Figure 3 an end view partly in section;

Figure 4 shows a side elevation of a modification of the joint of Figure 1 with straight bridging connections.

Figure 5 being a corresponding end view;

Figure 6 shows another form of joint in which the aligning means take the form of a rod and flange device; while finally

Figure 7 shows a longitudinal section through a form of triple concentric cable,

Figure 8 being an elevation of the bridging connection and adjuncts of the middle core and

Figure 9 a cross section on the line A B of Figure 8.

I wish it to be understood that the drawings are to a considerable extent of a diagrammatic nature while where desirable the same reference symbols are used to denote corresponding parts in the different figures.

In carrying the invention into effect according to one form (see Figures 1 to 3), the adjoining ends of the cable, *a*, to be coupled together are surrounded by a sleeve, *b*, tapered at the ends, and adapted to slide freely on the cables themselves. A certain distance back from the ends of the cables a number of lengths of flat copper braid, *c*, are electrically connected to one length of cable by binding with wire, *d*. The lengths of copper braid, are then passed across to the adjoining length of cable, so as to bridge the joint, being given a certain amount of spiral lay as shown, and their free ends are then bound in place as before.

In order to ensure that the sleeve maintains its proper operative relationship to the ends of the cables, during contraction or expansion, I may provide a shallow circumferential groove, *e*, at about the centre of its length, and bind the lengths of braid, *c*, to the sleeve in the neighbourhood of the groove by the binding wire, *f*, so that the sleeve always remains about midway between the bound ends of the copper braid.

According to a modification of the joint just described, I may as shown in Figures 4 and 5, arrange the flat copper braid, *c*, in straight instead of helical lengths or instead of flat braid I may use a braided tube of copper wire.

When desirable, in order to prevent, undue buckling of the braid on expansion of the cable, I may surround the joint with a tube, *h*, preferably of insulat-

ing material as shown in Figure 4, the scissors-like action of the wires of the braid providing for any further motion that may take place.

In the forms of joints above described, the flexible bridging connections, *c*, are preferably arranged symmetrically about the axis of the cable, both for mechanical reasons and also to provide the required cross-sectional area for the current.

It will be seen from the above description, and the two forms of the invention described in detail, that the essential features of the improved coupling consist in (*a*) suitable devices for maintaining the alignment of the adjoining lengths of cable, co-acting directly therewith, (*b*) appropriate methods of maintaining electrical continuity between the bridging connections and the cable lengths themselves, and (*c*) providing sufficient flexibility in the bridging connections themselves.

Each of these features may take different forms.

Thus, for instance, the aligning sleeves described, whether internally or externally disposed in relation to the bridging connections, may be sweated at one end if desired to the cable, or they may be replaced by the device shown in Figure 6 according to which flanges, *e*, are secured to the cable ends, one such flange carrying a series of projecting rods or bars, *s*, while the other flange is provided with corresponding holes through which such rods pass. Such an arrangement is in many cases convenient, since a copper spiral, *c*, can be disposed round each such rod and connected at its ends to the conductor itself or to the flanges as shown.

As regards the second essential feature of the invention, namely, the maintenance of the electrical continuity between the bridging connections and cables, many modifications may also be made from the forms described above.

Thus, for instance, the tapes or braids disposed round the cable may be clamped in place by screw clamps or they may be held in place by a collar screwed on to a conical thread on the exterior of a split sleeve, while according to another modification flanges may be provided on the cable ends as before and the outwardly or inwardly bent ends of the bridging connections clamped to the face of these flanges by an appropriate ring screwed or otherwise fastened in place; or again the flexible connections may be soldered or sweated to the cables. In other cases connections of circular cross-section hammered flat at the ends may be employed.

Furthermore, the necessary flexibility of the bridging connections may likewise be varied from the forms described above.

In small cables for example, a single spiral coil will be sufficient to provide for the movement of the cables while at the same time giving sufficient area for the current.

In other cases however, the flexible bridging connections may take the form of a flexible woven metallic tube, as indicated above, or the tape or braid connections whether flat or round may be bent to and fro into various patterns.

In any of the forms of my invention, a cable may be enclosed in a suitable box filled with oil or in a tube surrounding the coupling and plugged at the ends and itself disposed in a box filled with a bitumen composition or other suitable composition; or again the coupling may be enclosed in one or more tubes of linen or canvas to prevent the compound or oil getting amongst the flexible connections.

Although I have specifically described examples only of single core cables, it will be evident that many of the forms of coupling above indicated can also be adapted to couple multi-core and also concentric cables, the innermost core in the latter form being first dealt with and surrounded by suitable insulation and it may be also surrounded by a metal sleeve or the like on which to joint the next layer and so on.

Thus, referring to Figures 7 to 9, the inner middle, and outer cores are shown

respectively at a^1, a^2, and a^3, the usual insulating sheaths of the cable being indicated at b.

The inner core, a^1, is jointed in accordance with the method shown in Figure 4, the same reference symbols being used with the addition of an appropriate suffix and is surrounded with the insulating tube, h^1.

The wires of the middle core, a^2, are connected by binding wire, u, to metallic sleeves, r, thickened somewhat at the ends to assist the joint, these sleeves being adapted to slide easily on the insulating tube, h^1; a few turns of wire, w, may also be bound round the core, a^2, at the points where it leaves the insulating sheath within it. The adjacent ends of the sleeves, r, are finally connected by the lengths of braid, c^2, secured to them by the binding wire, d^2, the centre portions of the connections, c^2, being likewise bound by wire, f^2, to the insulation tube, h^1, within them.

The outer core, a^3, is jointed in precisely the same manner as the middle core, as will be understood on reference to Figure 7, the metallic sleeves to which are bound the wires of the outer core, a^3, on the one hand and the bridging connections c^3, on the other, sliding on the insulating tube, h^2. An insulating tube h^3 encloses the moving parts and is fixed to the external joint box.

Any suitable metal may be used instead of copper for the bridging connections.

I wish it to be understood that although I have described certain forms of my invention in detail and indicated how such forms may be modified in certain respects, I nevertheless do not intend to restrict myself to such forms or modifications, as it will be evident that the essential features of the invention pointed out in the earlier part of the specification may be embodied in a great variety of different forms.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. An expansion joint for electrical conductors, according to which the alignment of the conductors is maintained by one or more sliding sleeves, or like guiding devices co-acting directly with the conductors or with flanges or the like integral therewith, while the joint is bridged by flexible connections preferably arranged substantially symmetrically about the conductor and disposed either around or within the aligning means, substantially as described.

2. An expansion joint for electrical conductors in which the aligning means is or are connected to the bridging connections so as to maintain correctly the relative relationship of the aligning means and conductor during expansion or contraction, substantially as described.

3. An expansion joint for electrical conductors, in which the bridging connections are secured at their centre points to a sleeve or the like acting as the aligning means, substantially as described.

4. In joints as claimed above the use of metallic braided material for the flexible bridging connections, substantially as described.

5. Improved expansion joints for electrical conductors, substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 17th day of November, 1909.

MARKS & CLERK,
57 & 58, Lincoln's Inn Fields, London, W.C.,
13, Temple Street, Birmingham, and
25, Market Street, Manchester.
Agents.

Fig. 1.

Fig. 3.

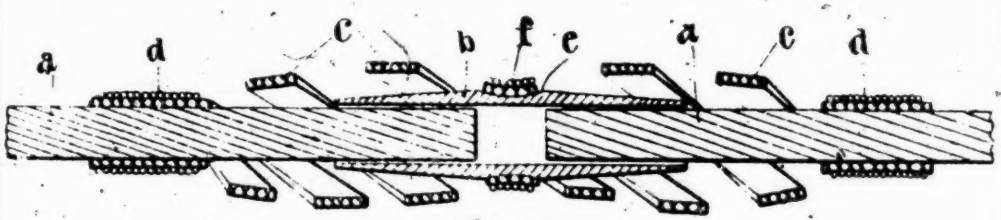

Fig. 2.

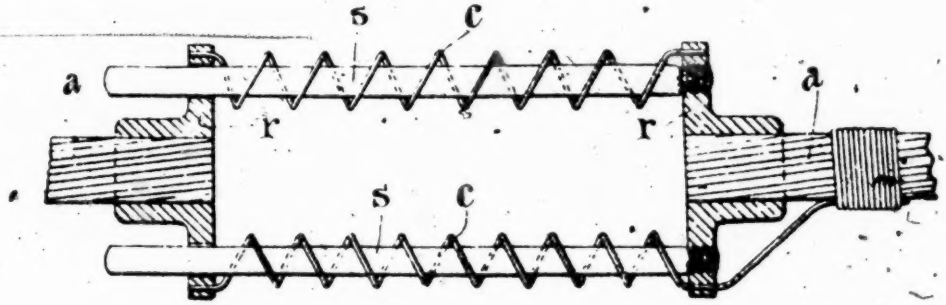

Fig. 6.

This Drawing is a reproduction of the Original on a reduced scale.

This drawing is a reduction.

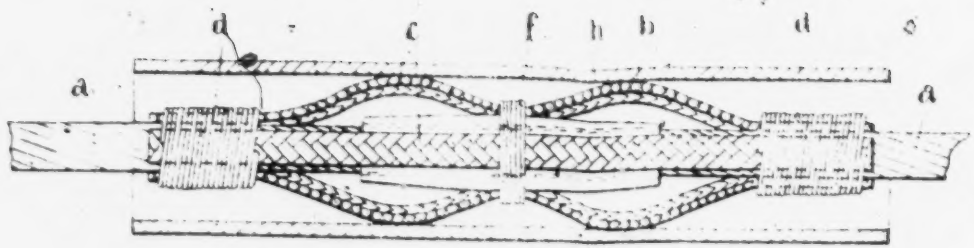

Fig. 4.

Fig. 5.

Fig. 9.

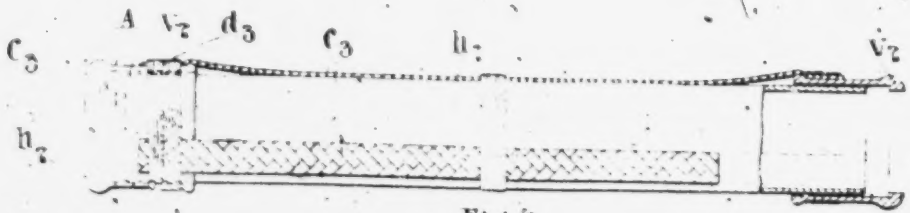

Fig. 8.

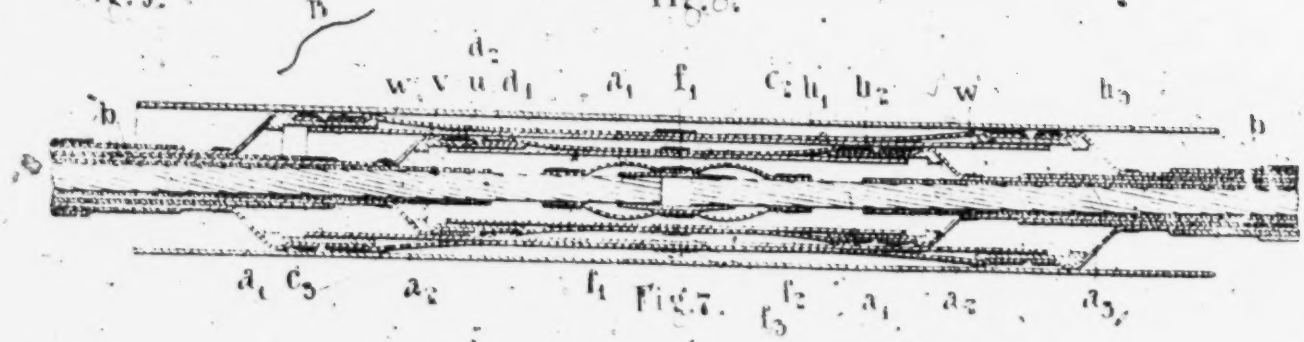

Fig. 7.

759

JOURNAL

OF THE

INSTITUTION OF

ELECTRICAL ENGINEERS,

ORIGINALLY

THE SOCIETY OF TELEGRAPH ENGINEERS.

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EDITED BY P. F. ROWELL, SECRETARY.

VOL. 47. 1911.

E. AND F. N. SPON, LIMITED, 57, HAYMARKET, LONDON, S.W.

SPON AND CHAMBERLAIN, 123, LIBERTY STREET, NEW YORK.

1911.

A.&.

Messrs. W. Clark and F. C. Polden were appointed scrutineers of the ballot for the election of new members, and, at the end of the meeting, the following were declared to have been duly elected :—

ELECTIONS.

As Associate Members.

James Cowie.
Charles Herbert Davidson.
John Ernest Hardey.
Duncan Clive M. Hume.
Henry McKenzie Kirkby.
James Brown Marr.
Arthur George Moore.
George Arthur Peck.
Reginald George Porte.
Alfred Roberts.
Adrian Hugh F. S. Simpson.
Frederick Symons.
Richard Henry Whittington.
Cecil Harry Wickham.

As Associate.

Stanley Herbert Stanley.

As Students.

Harry Oswald Addicott.
George Burton Alvey.
Reginald Charles Andersen.
William James E. Ball.
John Edwin L. Blythe.
Frederick Crossley Boa.
Phiroze Naserwanji Boga.
Walter Bull.
Edward Vivian Cheney.
Edwin Fowler Clark.
Ernest Arthur Elliman.
George Piercy Farrer.
Enrique Penard Fernandez.
Frank Fletcher.
Richard Vernon Hansford.
Ronald Graham Hargraves.
Thomas Joseph Hornblower.
Mehmet Ichssan.
Francis Munton Jackson.
Eric Maurice Johnson.
George Christopher Marris.
Horia Toan Nadejde.
Alfred Donald Newbury.
Clifford Anthony Newell.
Joseph John Page.
Douglas Harold Payne.
Ramanathpur Ramachandra Rao.
William Pearl Richardson.
Tom Riley.
Frederick Rowcliffe.
Sidney Bertram Smith.
Henry Stevenson.
Frank Charles Tomlins.
Thomas Charles Turton.
James Warren.
Alfred Woods.

Donations to the *Library* were announced as having been received since the last meeting from Macmillan & Co., Ltd., the Newcastle and Gateshead Incorporated Chamber of Commerce, S. Hirzel, Dr. R. M. Walmsley, G. K. B. Elphinstone, H. L. Webb, J. W. Warr, W. P. Maycock, W. S. Ibbetson ; to the *Building Fund* from J. H. Garratt and F. Gill; and to the *Benevolent Fund* from W. W. Cook, F. Gill, J. Gilligan, S. Insull, J. R. P. Lunn, F. H. Nicholson, to whom the thanks of the meeting were duly accorded.

The following paper, "The Laying and Maintenance of Transmission Cables," by C. Vernier, Associate Member (page 313), was read and discussed, and the meeting adjourned at 10.5 p.m.

THE LAYING AND MAINTENANCE OF TRANSMISSION CABLES.

By C. VERNIER, Associate Member.

(*Paper received January 25, 1911. Read before the* INSTITUTION *March 9, 1911, before the* NEWCASTLE LOCAL SECTION *March 6 and 20, 1911, and before the* GLASGOW LOCAL SECTION *April 11 and May 16, 1911.*)

When it is remembered that the mains system represents from 30 to 50 per cent. of the total capital expenditure on an electric supply undertaking,* and frequently exceeds the total cost of the plant and machinery, it is somewhat surprising that so very few papers dealing with the laying of mains have been presented before the Institution. This is, perhaps, all the more to be regretted as the subject is one upon which there is a variety of opinion as to what constitutes the best methods, and it should therefore provide good discussions. Again, it is one where mistakes may prove very costly, and a more frequent interchange of views cannot fail to be of general benefit to all concerned. It would be quite impossible to do justice to the whole subject of underground mains in any single paper, and in view of the more recent and extensive developments which have taken place in this country in the transmission of electrical energy for power purposes on a large scale, the author intends to confine his remarks to the laying and maintenance of underground transmission cables.

While America and the Continent can show longer transmissions than we have in this country, yet we are in no way behind in regard to underground work, and in one instance at least, viz., in our Northern counties, we can point to what is undoubtedly the most extensive system of underground E.H.T. cables in the world.

At this date it is scarcely necessary to consider any system other than the 3-phase alternating-current system for use on transmission schemes, as it has been almost universally adopted in all such schemes during the past ten years. The cables will, therefore, be invariably three-core paper-insulated and lead-sheathed, usually operated at pressures between 6,000 and 20,000 volts.

As this paper is concerned chiefly with the laying of these cables, it is not proposed to consider their manufacture. The author states this all the more readily as cables supplied by leading cable manufacturing firms are of a very high degree of excellence, and it is exceedingly rare

* The capital expenditure on mains of all kinds in the United Kingdom is probably not less than £25,000,000.

for breakdowns to occur as the result of faulty manufacture. Transmission cables will usually be laid on one or other of the following systems :—

1. Drawn into pipes or ducts.
2. Laid on the solid system in (*a*) wood, (*b*) earthenware, (*c*) cast-iron troughs, in each case with protective covers.
3. Steel tape or wire-armoured cables laid direct in the ground with either tile or wood plank covers.

Draw-in System.—The draw-in system has many advantages in congested districts where there is a likelihood of extensions being required along the same route, but generally it is too expensive for any extended use. While, for instance, its use might be justified, and in some cases even compulsory, in a large city, its cost would prove out of the question over a large and scattered area. Draw-in systems usually consist of separate earthenware pipes or multiple way ducts laid in concrete, with manholes spaced at suitable intervals according to the largest size of cable likely to be drawn in. Cast-iron pipes laid direct in the ground are also used, but their cost, unless the number of pipes is small, is greater than that of earthenware pipes. Bitumen fibre conduits, which are much used in America, have more recently been used in this country, and, judging from a limited experience the author has had of them, appear to provide an excellent system. The conduits are lighter to handle and more easily jointed than either earthenware pipes or ducts, and as they can be made in longer lengths the number of joints is considerably reduced. Further, on account of the flush joint, much less space is taken up and a good deal of concrete can be saved.

Single pipes provide greater safety than multiple-way ducts in the event of a short circuit taking place in the ducts. This is because instead of having a single wall of earthenware between the different ways, as in multiple-way ducts, two earthenware walls and a thickness of concrete which can be made as thick as required intervene between the different cables.

Single pipes also lend themselves much more freely to deviation singly round obstructions, without it being necessary to deviate the whole line of pipes. For these reasons multiple-way ducts are seldom used for heavy transmission work.

The design of manholes requires careful consideration, and it must be said often leaves much to be desired. It is of first importance that the cables should be so protected in the manholes that a breakdown on one cable cannot affect the other cables.

The arrangement of the cables should also be as neat as possible, and unsupported bends in the cables should be avoided. Fig. 1 shows a common type of manhole, where the cables have to be bent out of the pipes to the side walls. Accidents have occurred from manhole covers being dropped on to such cables. A much neater and safer arrangement is illustrated in Fig. 2, in which the pipes are gradually splayed out as they approach the manholes.

As far as possible, the pipe-line should not exceed two pipes in width, as otherwise the cable bend from the middle pipe is awkward to deal with. If this cannot be avoided, pilot cables and other similar less important cables should be drawn into the middle pipe or way. Manholes in wet situations should always be drained to the sewers, and where there is any likelihood of explosive gases being encountered, they should be ventilated as well.

The draw-in system does not afford the same protection to the cables as a well-laid solid system, as they are liable in certain cases to damage by chemical action from bad water draining into the ducts

FIG. 1.

from the surrounding soil, and as the pipes are frequently we electrolysis is greatly facilitated.

From these points of view cast-iron pipes, where their cost is not prohibitive, are to be preferred, as they can much more easily be made watertight by means of leaded joints, and if made electrically continuous throughout will act as a protection to the cables from electrolysis. The cables should be bonded to the pipes in a substantial manner at each manhole, and any electrolytic corrosion likely to occur will take place on the pipes, and the life of the cables thus be greatly increased. If E.H.T. cables are drawn into earthenware pipes or

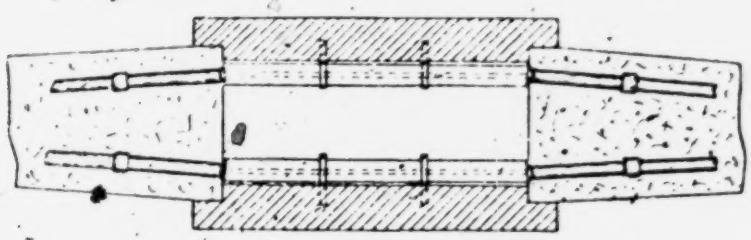

FIG. 2.

ducts, it is preferable to use wire-armoured cables, the armouring taking the place of the copper tape B.O.T. earth sheath under the lead, as this armouring and the protective coverings will add considerably to the life of the cables. Failing this, it is an advantage to use cables taped and braided over the lead sheath, as plain lead-covered cables are not sufficiently protected against chemical or electrolytic corrosion likely to be encountered.

All cable armourings and lead sheaths should be carefully bonded together, and also earthed to an earth-plate at each manhole. One

advantage sometimes claimed for the draw-in system is the facility for the carrying out of repairs, as it is only necessary to draw in a new length of cable. Those, however, who have had experience of repairs on both drawn-in and solid systems of cables will have no difficulty in agreeing that this is a doubtful advantage, as it is necessary in every case to draw in a whole length of cable between manholes in order to effect a repair, whereas on a solid system cases seldom occur where it is necessary to insert more than a few yards of cable.

Solid System.—E.H.T. cables when laid on the solid system are usually laid in either wood, earthenware, or cast-iron troughing filled in with a waterproof composition. There is very little difference in the cost of wood and earthenware troughing, and in many cases earthenware troughs can be obtained more cheaply. Earthenware, needless to say, is a much more lasting material than wood, and may be expected to outlast any cables which may be laid within it. The life of wood troughing, on the other hand, varies greatly, according to the kind of ground in which it is laid. It is usually greater when laid in wet clay than when it is laid in sand or ashes, owing, no doubt, to

FIG. 3.

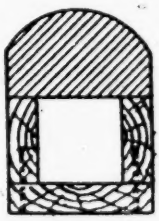

FIG. 4.

the exclusion of air. Opinions differ as to the preservative treatment to be used for the wood. Some object to creosoting, and specify that the troughing shall be treated with Stockholm tar. When this is the case, the usual method is to boil the troughing in the tar, but too often the makers will only soak the wood in cold tar, or the tar may even be put on like paint with a brush. When creosoting is ordered, frequently similar methods are used, and only a mere covering of the surface is obtained. In the author's opinion, the only satisfactory treatment is to impregnate the timber with creosote under pressure, as is done in the case of telegraph poles. Those who object to creosoting generally do so on the ground of possible chemical action on the lead of the cables, or again to a slight dissolving action which the creosote has upon the pitch or bitumen filling. Creosote obtained as a by-product of coal-tar distillation, if otherwise free from foreign matter, has no action upon lead or iron, but wood creosote obtained in the distillation of wood must be carefully avoided. The action upon the pitch filling is frequently absent, or so slight as to be negligible, but in any case is not at all a disadvantage, as it increases the adherence of the pitch to the troughs.

It is well to allow the surplus creosote to drain off before the

troughs are used, and no trouble need be expected in this direction. Wood troughing is not brittle like earthenware, and can be obtained in much longer lengths, thus decreasing the number of trough joints, and as these features are its only advantages, earthenware troughing is much to be preferred, except for situations where much vibration is to be expected, as in the case of cables laid along railways.

The construction of wood troughing is very frequently carried out in a wrong way, as shown in Fig. 3.

It will be noticed that the sides of the troughs are nailed to the bottom strip, and thus the weight of the soil above comes upon the nails which, in any case, quickly rust. It is frequently stated that the filling composition also acts as a support, but all filling compositions must be looked upon as fluids under long-continued pressure. Fig. 4 shows the correct method of building up wood troughing, in which it will be observed that the weight of the soil on the side-pieces is distributed on the bottom piece. Figs. 5 and 6 show various methods of jointing successive trough lengths.

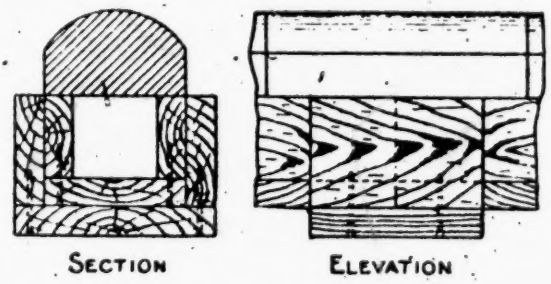

FIG. 5.

Earthenware troughing should be well glazed outside, but left unglazed inside. Pitch or bitumen does not adhere to a glazed surface, and this leaves room for moisture to creep in between the filling compound and the troughing. This is not the case with earthenware troughing which is unglazed inside, as the compound adheres closely to the rough surface. As already mentioned, the chief objection to earthenware troughing is the short lengths (about 2 ft.) in which it has to be manufactured, but in good ground this gives no trouble.

Cast-iron troughing is expensive, but makes a thoroughly sound system provided the bonding of the separate lengths of troughing is carried out in a thorough and substantial manner. The mere bolting of the troughs together, as is often done, is of very little use for this purpose. The lead sheath and cable armouring (if any) should be well bonded to the troughs at intervals, and in some cases iron supporting bridges are used which grip the cable and are screwed to the iron troughs.

Before leaving the question of troughing, it should also be mentioned that asphalt troughing is occasionally used. This consists of an asphalt-lined sheet steel trough in which the cables are

laid with bitumen. The usual cover consists of an asphaltic concrete, which further prevents the access of moisture to the inside of the trough. As the author has not had personal experience of it, he does not propose to discuss it further, but its chief point of interest lies in the claim which is made that cables laid on this system have their metallic sheaths perfectly insulated from earth. Cables laid on this system are also free from bridge troubles (which will be dealt with later) as with this troughing bridges can be dispensed with altogether.

The next point to consider in connection with the solid system is the filling compound. This is usually refined pitch, freed from any matter which might act chemically on lead or iron; or again, less frequently, Trinidad bitumen is used. Trinidad bitumen is two and a half to three times as costly as pitch, hence pitch is more often used; but there can be no doubt of the superiority of the former for cable laying. Pitch cannot be used in its natural state, as it is too brittle and has to be mixed in suitable proportions with a thinning oil in order to render it more plastic. The greater the proportion of oil the softer and more flexible the pitch. Unless therefore very great supervision is exercised in the mixing of the pitch and oil in the correct proportions (always a difficult matter) the pitch will be too brittle, and from his experience the author inclines to the opinion that pitch which has been put into the troughs mixed with thinning oil in such proportions as to be quite plastic does not retain this property indefinitely. Bitumen, on the other hand, is, in its natural state, a more tacky material, and it has the advantage of adhering more closely to the lead sheaths of cables and to the troughing.

The weakest part of the solid system is the supporting bridges for the cables. These were, until quite recently, made of wood, sometimes treated with preservative composition (generally Stockholm tar), and in some cases not treated at all. At first sight it would scarcely seem possible for cable bridges which are surrounded with pitch to absorb moisture, but after cables have been laid some time it is quite common to find the wood bridges wet.

Wood should never be used in contact with the lead sheath of cables, as in its decay, which must inevitably occur sooner or later, organic acids are produced which attack lead. This effect is more serious with some woods than others, oak being particularly bad in this respect. Cable bridges should therefore be made of earthenware, china, asphalt, or some other material not subject to absorption of moisture or to decay, and which is chemically inert.

All bushes required at trough and pipe ends should be of glazed earthenware, and this applies even more strongly to draw-in systems where such bushes are exposed to air and moisture, which greatly facilitate chemical action. Similarly all organic materials such as canvas, waste, etc., should be strictly kept clear of lead sheaths. Certain makes of cement also act chemically upon lead, and some engineers who have used conduits consisting of cement-lined steel tubes have experienced trouble from this cause. Asphalt bridges

have the advantage that the hot filling composition softens their surface and thus adheres very closely to them. This property is sometimes a disadvantage with heavy cables, as the bridges are liable to soften sufficiently to be crushed out of shape by the weight of the cables. This is not the case with the smaller sizes of cables, and for these probably no more suitable material can be employed. For heavy transmission cables the author prefers glazed earthenware bridges, and, in order to ensure the adherence of the filling composition, it is his usual practice to prepare the bridges by dipping them when dry in a fluid mixture of pitch and thinning oil, with which they become coated. This ensures adherence of the filling composition, as when it is run in, the thin coating, which has in the first place been put on to perfectly dry bridges, melts and the two surfaces adhere. Without this precaution, if the surface of the earthenware is at all wet, or even damp, the filling composition will fail to adhere. Figs. 7 and 8 shows designs of cable bridges, from which it will be noticed that the surfaces in contact with the troughs are reduced to mere points, so as to allow the filling composition entirely to surround them. The

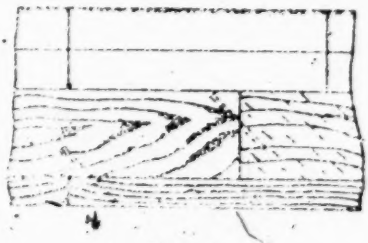

FIG. 6.

FIG. 7.

FIG. 8.

adherence of the filling material to the cables and to the troughs has already been mentioned. Pitch does not always adhere to plain lead-covered cables, especially if there is any moisture on the lead. Its melting-point being about half that of bitumen, it is also more liable to become chilled against the lead sheath, and it is frequently possible to break it off in flakes which retain the moulded shape of the cable and show the existence of a space between. Some engineers use cables with a braided covering for laying on the solid system, and this is much to be preferred, as the filling composition adheres very closely to such braidings. Others, again, lay armoured and jute served cables solid, and this may be considered the very best solid system of cables obtainable, especially if bitumen is used.

A good hard-pressed dome-shaped tile about 3 in. thick cannot be excelled as a protective covering for transmission cables, whether laid in wood, earthenware, or cast-iron troughing. Cast-iron covers, about ¼ in. thick, such as are often used, do not offer sufficient protection to a blow from a sharp pick. The dome shape is the best to glance off a pick point, and it is a good plan to have the tiles stamped either with the name of the owners or with the word "electricity," which act as a warning to excavators of what the troughing contains.

Z 65

It may further be remarked in passing that conduits when laid in concrete are much more liable than troughs to external damage. A block of concrete encountered in the course of excavations seems to offer an irresistible temptation to the ordinary excavator to set about its immediate removal with hammer and wedge. The method of indicating conduits shown in Fig. 9 is useful in such cases, particularly where conduits are laid across roadways which have a concrete foundation.

The solid system is not, in the author's opinion (who has had some twelve years experience of it), a thoroughly practical system to use for transmission work or any similar work on a large scale. While in theory it appears an ideal system, the practical difficulties in obtaining good workmanship in the conditions under which the work has to be carried out are very great, particularly in our uncertain climate. A shower of rain will frequently saturate everything—cable, troughs, bridges, etc.—while in dry windy weather dust and dirt get blown into the troughs. In waterlogged ground it is practically impossible to

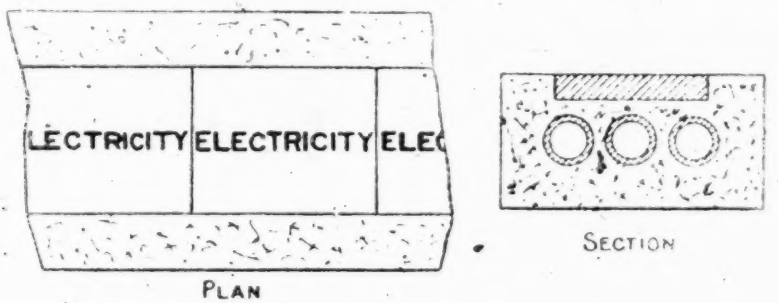

FIG. 9.

obtain good work, and owing to the shrinkage of the filling compositions the greatest care has to be exercised in order to get the troughs full and also free from blow-holes. The system has also very serious disadvantages attending on its great rigidity, which will be considered later.

Armoured Cables.—Cables are usually armoured with two overlapping layers of steel tape or with a single or double layer of armouring wires. Wire armouring is used in cases where tensile strength is required, and for transmission cables this type of cable is much to be preferred, for reasons which will be considered further in connection with subsidence and vibration troubles. Armoured cables (unless used solely to comply with the Board of Trade earth sheath regulation on the solid system) are usually laid direct in the ground, with a protective covering which consists of either tiles or creosoted planks about 2 in. thick, laid directly over the cables with about 3 in. of soil in between. Creosoted planks are considered more satisfactory, as tiles are very liable to be displaced and removed in the course of excavation near the cables by other companies. This is not the case with planks, as unless the full length of the plank, 12 to 14 ft., is opened up, they cannot be removed, and

wood gives a better warning. Further, a blow from a pick cannot displace them as in the case of a tile, and wood withstands many blows from a pick before it is penetrated. Armoured cables as generally supplied do not offer as good a protection from chemical action in bad ground as a properly laid solid system. The protective coverings usually consist of a serving of impregnated jute direct on the lead sheath, then the armouring and another serving of jute over this, the cable finally being passed through a bath of hot compound. These jute coverings eventually become sodden in wet ground, and this and any chemical matter with which it may be charged in some cases very quickly destroy the armouring and attack the lead. The popularity of the solid system in this country may be almost entirely attributed to some very rapid failures of armoured cable systems which have been experienced in the past. Armoured cables laid in dry sandy soils give very good results, while similar cables laid in made-up ground where decomposition of organic matter is liable to occur, or in ashes or in ground charged with sewerage matter, sometimes fail within a year or two, and in some cases even more rapidly.

It is the practice on the Continent to surround armoured cables with sand when other kinds of soil are encountered, and this has also been done in some cases in this country. This method adds very seriously to the cost of the work, as it is not only necessary to bring sand to the work, but also to cart away larger quantities of surplus soil. It is questionable whether a layer of sand is altogether an advantage except in very dry ground, which is more common on the Continent, as if there is any water about the bed of sand will act as a drain and keep the cable continually wet. Clay has been said to affect armoured cables injuriously, but this has not been the author's experience, although the soil in his district consists almost entirely of clay, and in bad soils it is better to surround the cables with well punned clay.

In dealing with the solid system, it has been pointed out that it has many objections for transmission work on a large scale the chief of which is the difficulty of getting the work done satisfactorily under adverse conditions of weather and similar inconveniences encountered when carrying on outdoor work on a large scale. This and the great rigidity of the system when laid, which gives rise to troubles arising from vibration, subsidence of the ground, and earth movements, render the use of armoured cables, which are better able to meet these conditions, almost imperative. Attention has therefore in some cases been directed to the improvement of the protective coverings on armoured cables, with an endeavour to render these coverings as good a protection to the cables as a good solid system, but with the very important advantage that the work can be carried out in the cable makers' shops under careful supervision and without any consideration of weather.

The improved coverings adopted, and which are now provided on all armoured cables laid by the power companies operating on the North-East coast, consist first of a layer of a flexible bitumen compound

⅛ in. thick coated directly on to the lead and served over all with two specially closely woven bitumen impregnated tapes. The cable is then served over these tapes with compounded jute yarn to form a bed for the armour, after which the armouring, either of steel tapes or wires previously passed through a bath of waterproof composition, is put on. This armouring is then served with jute yarn, passed through a bath of hot compound, and finally lime washed.

The total cost of the specially protected armoured cables when laid is very little more than the cost of plain lead-covered cables laid on the solid system, and with this slight extra expense a much more suitable system is obtained.

The Jointing of E.H.T. Cables.—The satisfactory jointing of cables is the most important operation in connection with cable laying. Even badly laid cables will often run satisfactorily for years, but badly designed joints, and especially joints of inferior workmanship, will prove a sure and constant source of trouble. The idea still commonly prevails that joint breakdowns must be taken in a philosophical manner as one of those things which are always with us and cannot be avoided. Joint breakdowns are, however, inexcusable at the present day, and any breakdowns caused by bad workmanship on the part of jointers should be severely dealt with. So much does reliable jointing rest in the hands of the jointer, that only thoroughly skilled men with a long period of training should be employed on important work like transmission cables. Again, workmanship being such an important factor in jointing, all improvements in design should tend to such simplification of the work as will diminish the necessity for this great skill.

In the design of E.H.T. joints there are three essential points which require careful consideration, viz.:—

1. The jointing of the conductors.
2. The insulation of the joint.
3. The making of the joint watertight.

With regard to the first point, the jointing of the conductors is usually carried out by inserting these conductors into a short copper tube, the joint being afterwards soldered. This form of joint is often very inferior. It is seldom that the tubes fit the conductors, and any sort of a fit is often considered good enough, as the joint will afterwards be soldered. In transmission work, however, the cables are capable of considerable overloading, and can safely be run continuously up to a temperature of about 150° F. Overloading and unloading of the cables throws a great strain on the joints, owing to the expansion and contraction of the conductors due to changes of load, and joints with poor contacts heat up and frequently pull out. The copper tubes or ferrules are sometimes split in two halves, bound together at each end, so as to tighten on the conductors, or again split on one side only to allow of being closed up to fit. As the shape of conductor used in three-core cables is seldom round, but approximately triangular in what is known as the "clover leaf" cable, round tubes can scarcely

be expected to make a satisfactory joint, except possibly with very small cables, which can be pinched to a circular shape. Because of this, many engineers specify that the conductor cores must be telescoped together. This form of joint, unfortunately, while a very great improvement from the point of view of electrical contact, is mechanically about the weakest joint which it is possible to use.

The author having given much attention to this question, recently devised a new method of jointing* which overcomes these disadvantages, and which, in its construction, is so simple as to ensure sound joints without the exercise of any great skill.

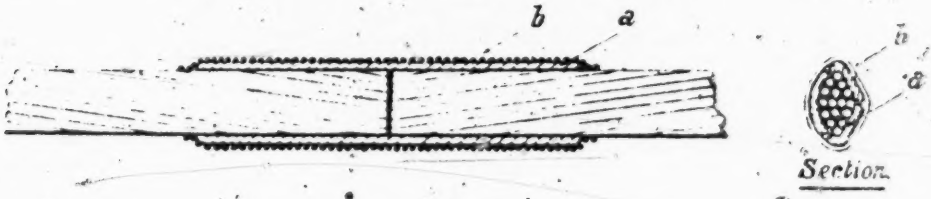

FIG. 10.

The method of jointing, which is illustrated in Fig. 10, consists in using strips of flexible copper braid (*a*) which are laid longitudinally along the conductors, and which are bound down on to them tightly by a circular binding of copper wire (*b*), the joint being afterwards soldered.

Joints of this type give a greatly increased electrical contact, as the flexible braid is compressed tightly into all the interstices of the conductor strand, and in proof of this it may be mentioned that a joint of this type made as in Fig. 10 and left unsoldered required one-third of a ton merely to pull one of the conductors out of the braids. A similar joint again unsoldered was run up gradually to 7,000 amperes per square

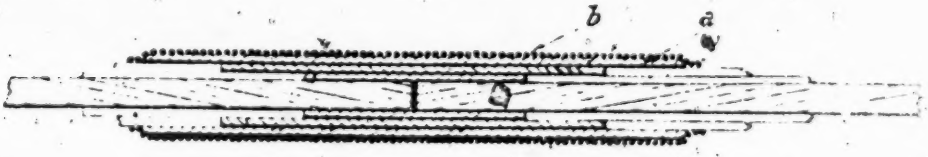

FIG. 11.

inch, its temperature rise being at all times lower than that of the conductor.

Fig. 11 shows an alternative type of this joint for heavier conductors which consists of more than three strands of wires. In this it will be noticed that the continuity of each strand can be maintained independently by separate layers of copper braid. The copper braid when soldered and dissected can scarcely be distinguished from solid copper so thoroughly does it become filled with the solder which it holds like a sponge.

* Patent No. [illegible] of 1910.

The second point for consideration is the insulating of E.H.T. joints. Figs. 12 and 13 show the two representative types of joints generally used for all working pressures up to 20,000 volts. Each of these two types have special features which it is important to consider in some detail, and the remarks which follow must be understood to refer especially to joints for 20,000 volts. At such high pressures the weaknesses of joints reveal themselves, and, as it should always be the ultimate object of the designer to construct joints which are in every way equivalent to the cable itself in regard to reliability, the experience obtained at the higher pressures may with advantage be extended to the construction of joints for lower pressures, *i.e.*, from 6,000 volts towards.

The insulation of joints may be provided in either of two methods, first by putting insulation on the conductors themselves, or by spacing them apart and using the filling composition as the sole insulating material. Fig. 12 shows a joint of the former type, in which the cores are in contact after each having been separately insulated by wrapping them up with an insulating tape. White linen tape boiled in resin oil just before using is more generally used, but in some cases tapes impregnated with special compounds at the factory have been used. These latter tapes cannot, however, compare with the former, as all tapes are liable to absorb moisture, and by boiling the tape in oil just at the time it is required all moisture can be extracted with certainty. Insulating tapes boiled in this manner are also saturated with oil, which is squeezed out in the process of wrapping on and fills all crevices between layers. Factory impregnated tapes are of a drier nature, and do not possess this feature. This, moreover, is an extremely important feature, as in E.H.T. joints the breakdown pressure is enormously reduced if air is present. When E.H.T. joints were first insulated in this way, it was a common practice to insert thin sheets of mica in between the wrappings of tape. It has, however, been found that joints insulated with tape and mica, notwithstanding the very great dielectric strength of the latter material, gave very much lower breakdown pressures than joints insulated with tape only. The difference is attributed entirely to the greater absence of air in the latter case.

The three cores, after each being separately insulated, are taped over together by another wrapping of insulating tape over their whole length in order to provide the same thickness of insulation between cores and earth as between the cores themselves.

In the second type of joint (Fig. 13), the conductors are separated from one another by an insulating spreader or separator, which may be either of ebonite, china, or similar material. The cores are sometimes taped over with insulating tapes, but with certain precautions this is not necessary and is best avoided.

High-grade joint-box compounds possess very high dielectric strength and withstand higher breakdown pressures than insulating tapes, but their great disadvantage is the considerable shrinkage which takes place on cooling, and the liability, if of a solid nature, for blow-

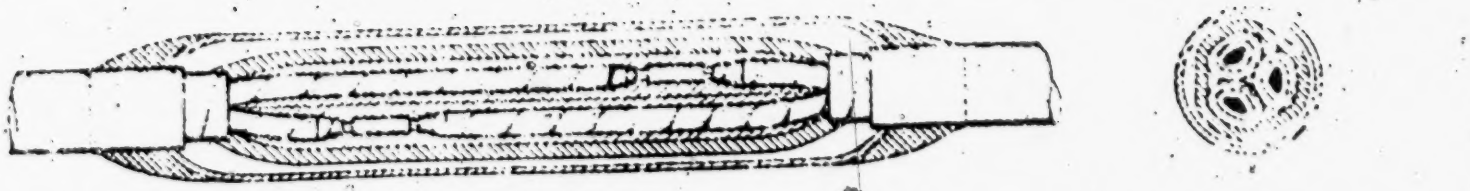

FIG. 12.

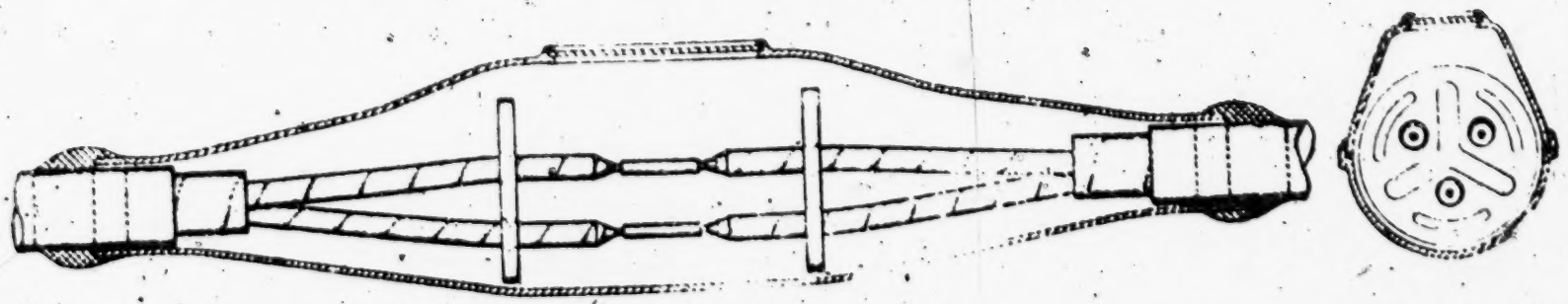

FIG. 13.

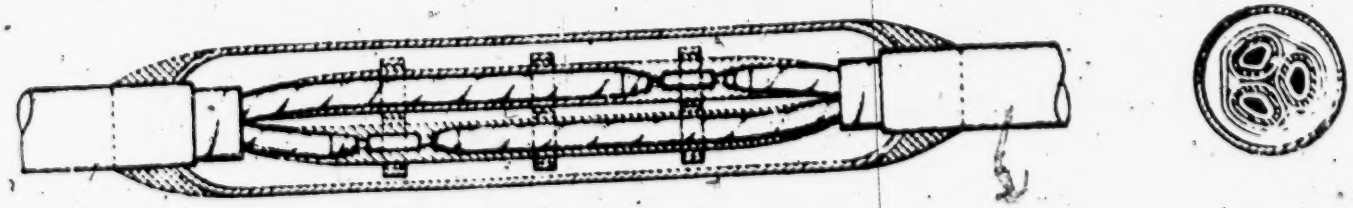

FIG. 14.

holes or air-pockets to form in their mass. The great importance of excluding air from all parts of E.H.T. joints has already been stated, and the two types of joints (Figs. 12 and 13) may now be considered from this point of view.

Joints of either type may be filled either with an insulating oil or a joint-box compound (of a solid or viscous nature). Oil is objected to by many engineers, who fear its being absorbed up the cores of the cables, and who therefore insist on a joint-box compound being used. Although one hears this absorption of the oil frequently mentioned, the author has yet to meet a case where a breakdown has occurred from this cause, and with cables impregnated under vacuum, as E.H.T. cables always are, the leakage should in any case be very small. The author considers it important that a joint insulated in the manner shown in Fig. 12 should be filled with an oil, and that the outer insulation over the three cores should be put on in the form of bands at intervals along the cores, as in Fig. 14, rather than wrapped over the whole length of the cores, as this, especially if a solid joint-box compound be used, will leave large air-spaces all round the cores which the compound cannot penetrate, and there is further a danger of the oil drying out of the insulating tapes. The cores should also be separated at intervals by similar bands of insulating tape, so as to allow the greatest possible freedom of access to the oil, which will keep the insulating tapes constantly impregnated, and this will be greatly assisted by the constant temperature changes which the cable undergoes under changes of load.

Considering the second type of joint (Fig. 13), in which the spacing of the conductors by means of insulating separators, together with the filling compound, is relied upon to provide the insulation of the joints; in cases where solid joint-box compounds have been used breakdowns have occurred due to shrinkage of the compound taking place in solidification after the joints have been filled. In large joint boxes of this sort the cooling takes place from the outside to the inside, so that the final shrinkage takes place in the centre of the mass of compound. The outer layers being already set before the centre part of the joint has solidified, the shrinkage tends to produce a vacuum, and if there were no air available a hole would form with a vacuum inside. It has been found, however, that there is always a certain amount of air present in the cores and insulation of the cable, due to the impregnating oils of the cables running out when the cable is cut, and also being dried out by the heat in soldering the joints. The net result of this is that the hole due to shrinkage always forms at the ends of the cores and draws out air from the cores. This air-pocket causes breakdowns of the joints due to sparking, which takes place from core to core across this air-space. By insulating the cores separately with insulating tapes before the joint compound is run in, this drawing out of air from the cores can be avoided, and breakdowns from this cause prevented. The objection to having oil-impregnated tapes surrounded by a solid compound which does not keep the tapes impregnated still

exists, however, and for this reason an oil filling should in such cases be used. With an oil, it is again objected that it may leak away up the cores of the cable, and on this account in a joint of this type the author prefers that the cores should not be taped over, and that a viscous joint-box compound be used which never sets and in which cavities cannot form. It should be said, however, that an insulating oil could be employed, provided the question of possible leakage from the joint box is guarded against. It has been proposed by one large firm to exhaust such joints by a vacuum pump previous to running in the oil, and this will no doubt effectually provide perfect insulation for all pressures and also prevent any possibility of leakage up the cable cores.*

Comparing both types of joints from the point of view of skill required in making them, joints of the type Fig. 13 have the advantage in this respect, as the conductors are well apart, and it is only a question of the right kind of filling composition being used. A weak point, however, is the insulating separators, which in some cases have caused breakdowns, due either to moisture on their surface or to a film of air arising from imperfect adherence of the filling compound, the joints breaking down to earth *via* this surface.

In joints of the type shown in Fig. 12, where the cores are in contact, breakdowns are certain if the jointer does not pay careful attention to the extraction of moisture from the insulating tapes; or if he does not put on a sufficient thickness; or, again, wraps it on in a slovenly manner.

A joint which the author considers more reliable than either of the two types already discussed, and one which, moreover, does not call for such great skill on the part of the jointer, is illustrated in Fig. 15. In this type of joint the insulation is provided by loosely fitting tubes, preferably micanite, which are sprung over the cores, the conductor joint being left bare inside them and the tubes overlapping some distance over the ordinary paper insulation at each end. The tubes, which are split on one side with a lap joint, are finally taped over their whole length with two layers of insulating tape to keep them together, and the three tubes are separated by star-shaped china pieces taped down to them, which keep them apart and centre them in the lead sleeve. This lead sleeve is then filled in with the insulating composition, either an oil or a viscous joint-box compound—preferably the latter—which can run into the tubes and all parts of the joint box. It is important to space the china separators as far as possible from the ends of the tubes, so as to increase the leakage path between cores and to earth. It will be seen that in a joint of this type the risk of puncture between cores, as in Fig. 12, is avoided, the workmanship is of the simplest description, and with a suitable joint box compound breakdowns are not likely to be caused by air.

Such a compound must be viscous and of about the consistency of thick cream at ordinary temperatures. When heated it should run as freely as heated oil, so as to penetrate all crevices, and it must

* *Electrician*, vol. 66, p. 962, 1911.

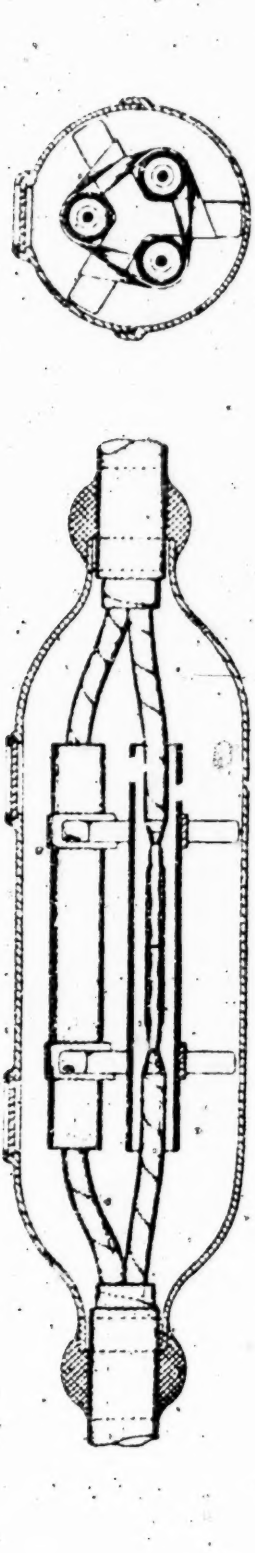

Fig. 15.

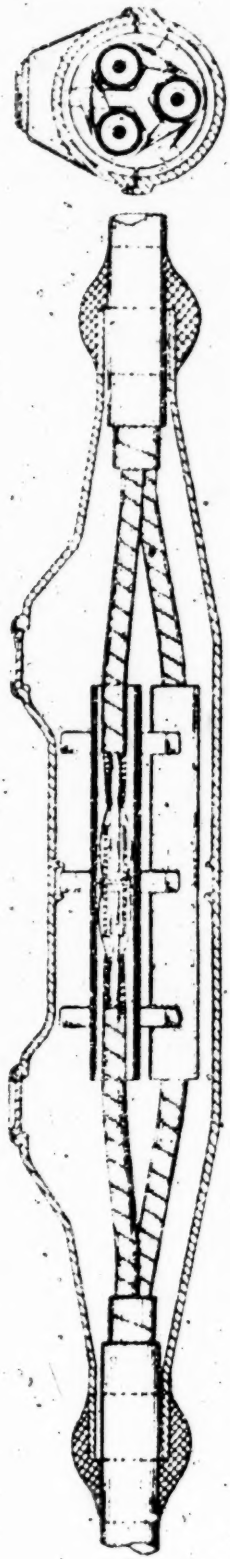

Fig. 16.

retain these features throughout its life; that is, it must remain a perfect mixture, and not be liable to have its thinning constituents, oil, and such like, separating out from the body of the compound, which consists usually of bitumen or resinous compounds.

Oils such as resin or other cable impregnating oils have been frequently referred to as suitable filling compounds; but if they are used they must always be carefully freed from all moisture before use, as oils frequently contain and absorb moisture from the atmosphere.

The third and last point on this question of jointing is that of the containing sleeve, and the making of the joint watertight. Lead sleeves are almost exclusively used in this country on E.H.T. cables, and are wiped on to the lead of the cable at each end and at all joints in the sleeve itself. Sleeves made out of drawn lead piping

FIG. 17.

(Fig. 12) are perhaps in greater favour, as sleeves of any length can be readily obtained, and they only require a wipe at each end. Cast-lead sleeves (Fig. 13) are less frequently used, and even less frequently cast-iron joint boxes are used. With the latter all joints in the castings should be faced to make them watertight, and the box should be bonded across by a bonding cable to maintain the continuity of the lead sheath across the joint box. This is necessary, as brass glands to which the cables are wiped are screwed in at each end of the cast-iron box, and these screw threads should not be relied on for electrical continuity. Another type of sleeve more recently used consists of a wrought-iron barrel, and is shown in Fig. 18, and should be similarly bonded across.

Lead sleeves provide for electrical continuity through the lead wiping, and require no further bonds, except with armoured cables in order to maintain the electrical continuity of the armouring. It is usual to enclose all joint boxes in an external wood or earthenware box filled in with pitch or bitumen, which acts as a protection against corrosion.

Usual Causes of Breakdowns.—Besides faulty workmanship, the causes may be generally summarised as follows:

1. External damage.
2. Chemical action.
3. Electrolysis.
4. Subsidences and earth movements.
5. Overrunning.
6. Vibration.
7. Pressure surges.

External Damage.—Breakdowns due to external damage are generally due to injury caused in the carrying out of excavations by other undertakers. These may result in picks or crowbars being accidentally driven into the cables, or, in the case of solid systems, to damage caused by undermining of the cables without properly filling in the ground afterwards. The author may have been more fortunate than others, but such cases have been rare in his experience, and would not average one case per annum over the past ten years. Other still less frequent cases of breakdowns due to external causes which the author has experienced, are leakage of steam and hot water from steam pipes in the neighbourhood of collieries and shipyards, destruction of the lead sheath by vermin, collapse of a dock retaining wall, and undermining of cables by leakage of water from water mains.

Chemical Action.—Chemical action, where care is taken in carrying out the work of laying the cables, should seldom cause any trouble. All material used in the work, such as pitch, oils, compounds, and linen tapes, as well as any suspicious water or soil encountered, should be submitted to a chemist for examination, and it may be remarked that in perhaps no branch of engineering work is there greater need for close co-operation between the chemist and the engineer. It is important to remember that once cables are laid down there is no opportunity of remedying mistakes except at very great cost, and that cables are laid down and expected to last for at least twenty to thirty years without inspection and with the minimum of attention.

Electrolysis.—Electrolysis on lead-covered cables is much more likely to give serious trouble before it is discovered, and is difficult to guard against, as the conditions which give rise to it may change frequently without any warning. Where bad cases of electrolysis have occurred it has generally been found to be due to excessive leakage from tramway undertakings or similarly from 3-wire continuous-current networks. When this excessive leakage has been removed and the Board of Trade regulations complied with, electrolysis has been greatly minimised, if not altogether prevented. Much more can be done in this way than by earthing or insulating the lead sheath, as is frequently done, although these additional precautions will assist in preventing corrosion. The whole question is very much simplified on transmission cables by the cables being as a rule few in number and following definite routes, whereas on an extensive lead-covered low-tension network with all the lead sheaths bonded together and covering a large interconnected area it is a much more difficult matter to deal with. Considering a transmission cable several miles in length, the danger zones can be pretty well clearly defined. Such a cable may possibly pass through a large city supplied with a 3-wire network and electric tramways, then pass on to a purely country district, and again into another tramway system. Tests can therefore be made at various points and evidence obtained of any conditions existing which are likely to cause electrolysis.

Apart from this, there are at least two well-defined and opposit-

views on the question of the safeguarding of cable sheaths from the effects of electrolytic corrosion, which are—

1. Earthing the lead sheath to earth-plates at frequent intervals.
2. Insulating the lead sheath from earth.

The principle underlying the first method is that a number of good metallic conducting paths should be provided at frequent intervals by means of which any current which gets on to the lead sheath may flow to earth instead of leaving the lead sheath through unintentional leakage paths, at which points corrosion will be set up.

Unfortunately, a low-resistance earth is most difficult to obtain with any type of earth-plate, and this difficulty is further aggravated by the extreme difficulty of getting any permanent insulation of the lead sheath to earth along the remainder of the route with any of the usual systems of laying. Practically all lead sheaths, whether laid on the draw-in, solid, or armoured systems, will test "dead earth" shortly after, if not at the time of laying. It is therefore a question of which path offers the lowest resistance to leakage currents, either the earth-plate or some other leakage path (such as at bridges, bends, and ducts) between the lead sheath and earth. If the latter, then current may leave at such places and set up corrosion.

The second alternative view—that of insulating the lead sheath from earth—is claimed for such systems as the Howard asphalte solid system and also bitumen fibre conduits. How far such systems are successful in this direction it would be interesting to know from actual users and from tests made a few years after laying. It cannot be overlooked, however, that even if the insulation is not perfect with such systems a combination of them with earth-plates at intervals would prove of considerable advantage, as what is required in thus earthing the lead sheath at intervals is that the resistance of this lead sheath to earth should at any point along the route be considerably greater than that of the earth-plates, including the resistance of the lead sheath itself between such earth-plates. Before leaving this question reference should be made to Messrs. J. G. and R. G. Cunliffe's paper on "Electric Traction Vagabond Currents," * in which it is pointed out that electrolysis is chiefly confined to metal pipes and cables laid within 3 ft. of tramway rails, and the author's experience, where the Board of Trade regulations have been adhered to, would seem to confirm this, but practically every case which has come to his notice has been due to neglect of these regulations.

Subsidences and Overrunning.—The next cause of breakdown to be considered is that of subsidences and earth movements, together with which the question of overrunning may also be considered, as all give rise, similarly to expansion and contraction of the cables. Undertakers operating in colliery and other mining districts at times experience serious trouble from the pulling out of joints or cable breakdowns due

* *Journal of the Institution of Electrical Engineers*, vol. 43, p. 449, 1909.

to subsidence of earth movements. These are much more frequent on solid laid cables than on either drawn in or armoured cables, although none of these systems can be said to be altogether free from this trouble. Sometimes the opposite effect, viz., that of compression of joints or of cable bursts, is met with.

When the ground subsides, the lead sheath offers little resistance, and is able to stretch quite easily, and provided the movement is not too sudden, it is in most cases unaffected. The conductors, however, do not stretch, with the result that a great strain is put upon them, and the conductor joints being generally the weakest point, these joints pull apart. It has been found that laying the cable with slack or snaked in the ground will not prevent this occurring, unless this snaking is done quite loosely in an empty trough, so that the cable can pull quite freely over long distances. The conductors will transmit the stress upon them to the joints quite easily round bends, or any waving in the cables after the manner of the wire in the Bowden brake commonly used on cycles. Cases of compression are generally caused by earth movements, which in some cases are quite extraordinary. Cables have been known to have a particular joint pulled out at one time and compressed shortly afterwards. In order to overcome troubles of this sort, the author has designed an expansion type of joint which is illustrated in different types of sleeves in Figs. 16 and 18. The method of jointing the conductors is shown on a larger scale in Fig. 17 and consists of a guide tube (*a*) in which the conductor ends can slide freely, the electrical continuity of the conductors being maintained by strips of flexible copper braid (*b*), which are bound down to them at each side and to the guide tube in the centre in order to maintain the relative positions of the working parts. The insulation of the joint is on the lines already advocated and shown in Fig. 15, and need not therefore be described further. The joint is finally filled with a viscous joint-box compound, which does not interfere with the movement of the various parts. Joints of this type have been in use for about eighteen months on several 20,000-volt cables on the power companies' systems in the Newcastle district, and have given very good results, no breakdowns of the joints or of the cables having occurred since their installation, although previously this such breakdowns were very frequent. Joints opened up for inspection have shown movements of over 2 in. to have taken place, in some cases, in a few weeks. The latest joints installed provide for 6 in. movement in all, but joints can be made for much greater limits of movement if required.

It is important that all joints in the affected area should be of the expansion type, and it is not sufficient to insert such joints only at intervals, leaving ordinary non-expansion joints in between, as the latter will almost certainly be affected, notwithstanding the expansion joints on either side.

Again, transmission cables are at times loaded up to very high-

* Patent No. 13,140 of 1900.

current densities, either in cases of emergency or in order to defer the incurring of heavy capital expenditure in laying additional cables. This matter has already been referred to under the jointing of the conductors, in which the great strains which come upon the joints in such cases have been pointed out, but the actual expansion and contraction which takes place in cables needs emphasising, as this is frequently overlooked. Assuming a cable is laid in the ground and jointed up originally at a temperature of 60° F.,* with a safe increase of temperature of 90° F., the conductors will expand 4 ft. 6 in. in a mile. The lead would, under similar conditions, expand 7 ft. 4 in.; but its temperature in the first place will always be lower than that of the conductors owing to the larger radiating surface, and again it will adjust itself to the expansion and contraction of the conductors owing to its ductility. It is somewhat surprising that means for taking up such movements are not usually employed on cables, as is done on practically every engineering structure and on pipes, although in these cases the changes of temperature are nothing like so great. For these reasons the author strongly favours the insertion of expansion-joints on all transmission cables, which will enable such cables to be run up to any current density which the paper insulation will stand, with the certainty that the joints will not fail at a critical time. It should again be noticed that the solid system is not one which adapts itself to such expansion and contraction movements.

Vibration.—Power and railway companies who have cables laid alongside railway lines frequently experience breakdowns caused by the breaking of the lead sheath due to vibration from passing traffic. This source of trouble seems to be confined entirely to cables laid on the solid system, and takes place at the joints of the troughing. The vibration produces, first of all, crystallisation of the lead at these points, and finally the lead breaks through. The smaller the cable the more severe is the trouble, and even if a small cable and a large one be laid alongside one another in the same trench, the small one will always fail first. This would appear to be due to small cables being set into vibrations of greater amplitude owing to their smaller weight, but no doubt it is only a question of time before the larger ones also fail. Although it might be supposed that very great vibration such as may be expected on railways is necessary before this trouble occurs, serious cases have occurred on lead-covered cables laid within 2 ft. of tramways which were laid on a bed of concrete in the usual manner. The remedy for this trouble is to use only armoured cables laid direct in the ground and at greater depth than usual if within, say, a distance of 4 ft. from rails.

Pressure Surges.—Resonance, fortunately, is not a very common cause of failure under normal conditions of working. Cables have usually a very heavy factor of safety (between 10 and 20, as a rule) for short periods. For this reason it has been found quite practicable to switch on and off long feeders direct on to the system without using

* On cables jointed in winter these figures will be much exceeded.

any charging devices. Nothing else has ever been done on the large power companies' systems on the North-East coast, which were first put in operation in 1901, and it is therefore somewhat surprising to learn that cable-charging gear was still in use on some other large undertakings as recently as 1904–1905.*

When pressure surges are the cause of breakdowns of cables or of their joints, it is usually the result of a heavy short circuit, which sets up oscillations in the system, and cables may break down due to a rise of pressure at some point often miles away from the short circuit causing the disturbance. There can also be no doubt that the system persists in a condition which may give rise to further pressure rises for some time, as breakdowns often follow upon one another within a few days. Breakdowns on cables caused by pressure surges are usually quite characteristic and easily recognised when an instantaneous protective gear, such as the Merz-Price, is installed. The insulation is generally perforated as if drilled through, or, if the breakdown is in a joint, fine burnt cracks are found through the insulation.

In conclusion, it will be noticed that a large proportion of the breakdowns experienced arise from the use of lead for the outer waterproof sheath of cables. Of all the metals lead is probably the only one which can be conveniently used; but it would be an advantage to use a non-metallic waterproof sheath, if one could be obtained, which retained the great advantages of the present lead sheath without its disadvantages. Hitherto it has not been possible to obtain any such suitable material, and the problem is not an easy one to solve.

Discussion.

Mr. Snell.

Mr. J. F. C. Snell: As there is so little time left this evening for the discussion, I will try and set a good example by keeping to the ten minutes rule. We have listened to an extremely practical paper, but it so bristles with details which one could take a whole evening to discuss that I must only touch upon the more salient of them. I notice that, so far as the systems themselves are concerned—that is, the solid system or the drawn-in system—we are practically in the same position that we were when this matter was discussed some seven or eight years ago. It may interest you to know that last year when abroad I had to examine a high-tension system which had been laid for some years. The cables were laid in a Howard asphalte trough, and the ground in which the troughing was laid was very full of chemical impurities. The result was that the outside steel surrounding the asphalte had entirely corroded away, but the asphalte itself was just as intact as it was on the day it was laid, and the whole system was in an extremely solid and good condition. I am also reminded by the author's paper of a very bad slip on an embankment that I experienced some five or six years ago. Some 6,600-volt cables, fortunately for us armoured, were laid along the side of a very steep

* *Journal of the Institution of Electrical Engineers*, vol. 36, pp. 85 and 120, 1905.

embankment, supplying an important shipyard in which some 7,000 or 8,000 men were employed. After very heavy rains, followed by a frost and then a thaw, the embankment slipped. These two cables, which were 3-core, 0·1 sq. in., I think, in section, were left supported between abutments 40 yards apart, and they not only held up their stoneware troughing and the bitumen and covers which surrounded them, but also something like 18 in. of clay filling above and a line of paving stones. The weight upon those cables must have been very great indeed, and yet when the whole thing was cleared away there was no sign of any stretching of the cable. If they had been merely lead cables the lead would undoubtedly have drawn and the cables would have broken down. In that case the double-wire armouring undoubtedly saved the cables. May I draw attention to one other practical point which I have come across during the last twelve months? I had occasion to examine some cables which had broken down badly on a railway embankment, and I can verify what the author says, that the continued movement of an embankment caused by the passage of trains—in this case rather heavy freight trains—undoubtedly causes the cable to "work." I suppose what had really happened was that the stoneware trough in which the cables were laid had been disturbed by vibration and had worked at the joints, the bitumen at the joints had been gradually broken away, and then the troughing edges had gradually indented the lead until the lead was broken; possibly the movement of the whole embankment had caused the lead to crystallise and to break through. To get over that we took the precaution to lay armoured cables, with a cushion between the lead sheathing and the armouring, not quite in the same detail that the author describes on page 321 of his paper, but somewhat similar. We laid it in this case in a wood troughing instead of in stoneware. It seems to me there is one important matter in the laying of cables on a solid system that has to be borne in mind, and that is the quality of the bitumen or insulating compound which is used to fill in the spacing between the stoneware or wood troughing and the armouring of the cable or the lead sheathing, as the case may be. With the help of Mr. W. P. Digby, who made a number of experiments in his laboratory, we have been using for some time past a bitumen refined to a certain specification, and it may be of assistance to some of you, and it may also be subject to criticism on the part of some of the cable manufacturers, to tell you what that specification is. I do not know that there is anything very original in it, but it does embody, as far as I can see, all the important details. Of course it has to be softened by the addition of a certain oil, and it must be free from wood and coal-tar pitch, from sulphur compounds and from resin. In other words, you want to get as much as possible a homogeneous compound. We specify that it shall not contain a greater percentage than 35 per cent. of ash, and that its ductility—which is a very important matter—shall be such that at a temperature of 82° F. it shall begin to flow, and that it shall flow freely at a temperature of 100° F. Some considerable experience of

Mr. Snell.

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that compound has shown us that it is to be trusted. Although a great many people might think it is quite an unimportant detail, I do think that the selection of the bitumen, or, at any rate, of the material which is to surround the cable and protect it for many years, is of the very greatest importance.

There is one last matter to which I will refer, and it is this. The author speaks of the protection of the cables from electrolysis. It is a debatable matter whether or not one should deliberately earth the sheathing of the cable at certain definite points. Although there is much to be said both for and against, I think the better way is deliberately to earth the sheathing of the cable at certain defined points, because then we know what ills we may suffer from, whereas if we do not do that we may fly to other ills we wot not of. I should like to ask the author whether, in the vacuum process for forming his joint, it is not a fact that, with the viscosity of the liquid which he uses to fill the joint-boxes, he does not get air spaces left in the joint-boxes due to the soaking up into the spaces between the conductors and the dielectric which have been left by the process of vacuum extraction—that is, the extraction of the air from the spaces between the dielectric and the conductor. And, lastly, I would ask the author if he can give us two other particulars, namely, the temperature limits of these 20,000-volt cables and the current densities that he is able to work these cores at under emergency conditions. Particulars have been published in the *Proceedings of the American Institution of Electrical Engineers* upon this subject, and I think they have been quoted in Hobart's book, and tables and diagrams have been shown, but nothing that I can see refers to cables working at the higher pressure of 20,000 volts. I believe it is understood that they may be worked up to current densities of something like 1,800 amperes per square inch and yet keep within a reasonable temperature limit. If the author can give us any reliable particulars upon that point he will, I think, add much to the importance of this paper.

Mr. Welbourn.

Mr. B. WELBOURN: Speaking as a cable man, I look upon this paper as an excellent corrective to the recent papers we have had on high-tension pole lines. I am very glad to hear the author accept the fact that paper-insulated lead-covered cables are the only practical means of transmitting energy underground nowadays. So far as I know, this is the first time it has ever been declared publicly. The author deals, in two or three brief remarks in his paper, with the expected life of paper insulated cables, and in one place he mentions that the probable life will be from 20 to 30 years. I would like to ask the author what evidence he has in support of that statement. I have looked into the question very carefully at times but consider there is no supporting evidence. Paper-insulated lead-covered cables have been in use now for 21 years in this country. The copper certainly will not deteriorate, and careful examination of the paper after 20 years' use shows no deterioration, so far as we can tell from microscopical, chemical, and tensile tests. Therefore the

question really comes down to the life of the lead pipe. The gentleman who introduced paper-insulated cables into England once told me that lead pipes in good condition had been dug up at Herculaneum. [Mr. HAMMOND: With cables inside them?] No, water-pipes. Of course in England, and in all densely inhabited countries, the conditions underground are different. There may be organic matter present which will attack a lead sheath unless it is properly protected. The author on that point accepts the fact, I think, that wherever we bury a cable underground and do not go in for a drawn-in system, we should lay an armoured cable. I think the author sets that out very clearly in his paper. I am very glad to see this because there are many here to-night who have heard me speak on this subject in private. I have felt strongly for years past that the armoured cable, where it is necessary to bury a cable direct in the earth, is the right solution of the cable problem, because one knows it is very difficult to get a proper solid system in the streets where you have to deal with variable climatic conditions and also with unskilled labour. There have been certain developments recently in the methods used for protecting cables, especially armoured cables, which are not referred to by the author. I think it is now quite correct to claim that one can make in the factory with skilled labour and send out ready for laying, a much better solid system than one can ever make in the streets. I might mention, in confirmation of what I am saying, that the Home Office Committee on the use of Electricity in Mines has just given a very emphatic endorsement to the use of properly armoured cables for underground colliery conditions, where sometimes there are very corrosive waters which would attack the armouring, were it not properly protected. One thing that has militated in this country against the use of armoured cables has been the attitude of the Local Government Board in granting only short-period loans to Municipalities. I think I am right in saying that they grant loans for armoured cables for only 15 years, whereas for the solid-system work they grant them for 25 years. I suggest there is scope here for the Institution, either alone or in conjunction with the I.M.E.A., to educate the Local Government Board. Then the author deals somewhat lengthily with the important question of electrolysis on lead-sheathed cables. Speaking of feeder cables only at the moment, I wish to state as the result of my experience—and state it very emphatically—that a case of electrolysis need never occur. There are, as the author has stated, two schools of thought on this question, and, with Mr. Snell, I most emphatically belong to those who believe in earthing at definite points, and in maintaining the electrical continuity of the lead sheathing. Where we have an armoured cable there is one point that should be borne in mind that is not always realised, and that is that not only should we maintain the continuity of the lead sheathing, but we should also maintain the conductivity of the armouring at its full value, and we should take as careful steps to earth the armouring as the lead. If those simple precautions are taken there is no doubt that the trouble which has been alleged

Mr. Welbourn.

would not be experienced. I had intended to deal somewhat at length with the question of earthing, but possibly that is rather outside the scope of this paper. I would say, however, on this earthing question—because it is a very important one indeed—that when the sheathing of a cable system has once been earthed it should not be assumed that it is going to be right for all time. Earthed wires do corrode, and there is also some reason to think that the electrical conditions underground do alter with the opening of electric railways, electric tramways, and so on. I have come across definite cases where earthing has been carried out, years ago, and the recent insertion of an ammeter in the earth wire has shown that not only is the earthing not doing any good, but it is doing harm, because current is leaving the earth and going into the lead sheathing, and, unless the other earths that are on the system are efficient, that is going to lead to trouble. The earthing arrangements need overhauling from time to time.

With regard to the question of jointing, which is an extremely important part of the paper, I think the author has hit on two very good devices in his braided joint and in the expansion joint. The braided joint seems to me to be so self-evidently good that it is hardly necessary to discuss it. I would like to ask the author, however, what was the section of the conductor on which he made the tests mentioned on page 323, which are very striking if the section of the conductor is comparatively small. The expansion joint is a great step forward, and meets a long-felt want among cable engineers. I have no doubt whatever that, on power systems and on heavily loaded mains, these expansion joints will be very extensively used. I expect there are engineers present who will be able to tell us their experience of troubles which could have been overcome by the use of these expansion joints. One that I am acquainted with on a high-tension system was where an open circuit was found. On going to look for the trouble, which was due to subsidence, the cable was found about 10 ft. deep. The cable insulation was perfectly sound, the joints were of the telescoped type, wrapped with copper wire and soldered, and the soldering had fortunately been badly done. The subsidence had pulled the cores apart, the binding wire had unwrapped and maintained the circuit until a transformer at the far end of the line failed; the wire acted as a fuse, and quietly put the cable out of business. It is a very good feature that the author has directed our attention to the jointing of 20,000-volt cables. Up to the present, the results with joints for 11,000 volts have been extremely good. I have made thousands of 11,000-volt joints without having the slightest difficulty. But pressures have now gone up to 20,000 volts and even higher, and possibly one must reconsider one's methods. The author has mentioned 30,000-volt cables, and I am not sure that 40,000-volt alternating current cable is not within the region of possibility, provided the user understands that he is buying a cable that has not the same factor of safety that a 30,000-volt cable or a 20,000-volt cable

has, and provided also he will run it at a fairly low temperature, current density, and frequency. With regard to the question of trouble due to vibration on railways, I have found that a very good rule is to lay the cables 4 ft. deep, 4 ft. away from the nearest rail; and wherever it goes under a track to lay it not less than 6 ft. deep. If that simple rule is followed, I think it may be taken that no trouble will ever result with wire-armoured cables. Mr. Welbourn

Mr. J. S. HIGHFIELD: The whole of this paper deals with the difficulties of laying cables, jointing them, and using them, and not with difficulties connected with the cables themselves. Mr. Welbourn has said that the difficulties of the cable from the point of view of the design and manufacture are almost negligible. I think it ought to be so, because the cable as it is made to-day is an exceedingly expensive piece of apparatus. I agree with what Mr. Welbourn said as to the advantage, if a solid system must be laid, of making that solid system in the factory and not trying to construct it in the street. In my experience it is an exceedingly difficult thing to lay a solid system in ducts which is absolutely as satisfactory as one would like it to be; and so long as the ground is good and there is not much subsidence, I am inclined to hold that the drawn-in system is not only cheaper, but is also superior. I want to say just a few words on the question of jointing. I speak particularly of concentric cables, because I have not tried the method I intend to mention with 3-core cables, although I have no doubt there would be no difficulty in using it. Some time ago the Metropolitan Company had a certain number of joint failures with 10,000-volt cables—not very many, but still, three or four failures which were rather awkward. That resulted in the engineers who have charge of the mains system investigating the question of joints rather carefully. The joints were first made by tapering the paper over 5 or 6 in., bringing the insulation into a cone form, then winding the joint with tape and sometimes with mica, and building up a layer of insulation rather thicker than the original insulation. On test these joints were found to fail at 30,000 to 40,000 volts alternating at 60 cycles, and the failures in every case occurred through sparking where the tape abutted on to the paper. As a result of that, stepping was tried; that is to say, instead of making a smooth cone, we made 4 or 5 steps in the paper, using the tape again without the mica. The effect of that was to raise the breakdown pressure to something between 50,000 and 60,000 volts. We then tried to make the joints entirely of paper, using no tape. A similar class of paper was used to that with which the cable is insulated. The paper strip was wound carefully on to the stepped insulation, and we found that we could obtain test pressures of about 60,000 volts. The number of steps was then altered, and we finally adopted 5 steps, formed by tearing off the paper, not by cutting. We took the further precaution of winding the impregnated paper on a reel so as to avoid any contact with the jointer's hands. In this way we made a joint quite free from moisture. With this type of joint we obtained pressures up to 84,000 volts alternating without breaking down Mr. Highfield

Mr Highfield.

the joint. We have had joints insulated in this way stand 130,000 volts alternating for a few minutes. This method makes an extremely inexpensive joint, and I prefer it to any other. Then I would like to say one or two words about the testing of long lines of cables. A long length of cable constructed for 10,000 or 20,000 volts pressure requires a very high charging current. Apart from the fact that a large amount of expensive machinery is necessary for providing this current, I am not at all clear as to the effect of that sort of stress on the cable itself. The cable manufacturers could probably tell us more about it. I have tested cables and joints up to 130,000 volts with alternating current, and have found that when they break down they do not break down through a clean electrical puncture, but owing to the heat which is generated in the joint by the energy lost in the form of dielectric hysteresis. I have tested similar joints in cables with pressures up to 150,000 volts direct current, and no difficulty is experienced. There is no heating, and very little power is taken.

I am decidedly of opinion that much the best method of testing long lengths of cable, even when they are for use with alternating current, is to use a very-high-tension direct current. It is quite easy to obtain a direct-current pressure up to 300,000 volts, and as there is no charging current and only leakage current has to be dealt with, a machine of less than 1 k.w. is capable of testing very long lengths of cable. I have tested about 14 miles of cable with a machine which gives something under ½ k.w., the bulk of the loss being due to discharge through the air. The advantage of using direct current is not only that a much smaller machine can be used, but the pressure can be much more accurately measured, and the electrical stress to which the cable is subjected can be accurately controlled, and, owing to the fact that there is no heating, there is far less risk of damaging the cable when this method of testing is used. Great caution must be exercised, however, in discharging the cable after testing it at these high direct-current pressures as the cable will retain a considerable charge, for several days even, after it has been earthed.

Mr. Patchell.

Mr. W. H. PATCHELL: I should like to ask the author what authority he has for the reference on page 315 to "the copper tape Board of Trade earth sheath." I have always understood that such sheathing was not a Board of Trade compulsory system. The Board of Trade has been blamed for a good many things, but I do not think it is quite right to blame them for that. I believe the arrangement was offered to the Board of Trade by a cable manufacturer and accepted by them. The manufacturer then said it had the Board of Trade blessing and sold it. With regard to the question of burying cables in clay, I have frequently had to cart clay to places where the virgin soil was bad, and we have had no trouble with the cables after that. In colliery districts particularly it is very often advisable to lay the cables in clay, and to be very careful in doing it. The vacuum joints interested me very much. We have been used in the last few years to seeing the Post Office and the National Telephone Company using pressure

blowers for drying out the air cores. I understood that pre[illegible] blowers were used because there was a danger of a vacuum dra[illegible] moisture into the cable. The author does not appear to fea[illegible] danger of drawing water into his joints, and I should like to [illegible] if he has had any trouble in that direction. It is very nice if we [illegible] to exhaust a joint to be able to do in the street what we are [illegible] generally accustomed to doing in the factories by putting the [illegible] into the vacuum tank, carefully exhausting it, and then letting in [illegible] impregnating oil, whatever it happens to be, but I thought it [illegible] a little risky to try and reproduce that result under street condit[illegible] I quite agree that a great deal of trouble has been caused on cable joints due to the dirty handling of the jointing materials, however good the material. In connection with my paper six years ago* describing the cables in the Bow system, I laid stress on that point and micanite tubes which were being brought forward at that time to get over a great deal of the difficulty were mentioned. Mr. Highfield has reiterated that point to-night. If the paper or tape is to be put on in the streets it is best to have it on a reel, and not to let the jointer handle it more than is absolutely necessary.

Mr. ROGER SMITH: At the bottom of page 317 the author refers to cables laid solid in asphalt troughing, and invites information as to results obtained. Something that I should have said has been already anticipated by Mr. Snell; but I might perhaps mention an experience with high-tension cables, working at 6,500 volts 3-phase, laid on the Great Western Railway between Park Royal generating station and three sub-stations. These cables partly serve the electrified tract between Bishop's Road and Hammersmith and Addison Road for traction purposes, and partly supply power and lighting for Great Western purposes. This is only a small system from the author's point of view, the total route miles being 9½, with 27 miles of high-tension 3-core cable up to the sub-stations, 10 miles beyond sub-stations and 14 miles of low-tension concentric cables, making about 51 miles altogether. After full consideration Howard asphalt troughing, laid on a 4-in. bed of concrete, was provided for all the cables enumerated above and in addition for a multicore telephone cable. The high-tension 3-core cables were paper-insulated, lead-covered and wire-armoured, while the low-tension cables were only lead-covered. The reasons for choosing this system of laying were very much those set forth in the paper, namely, the avoidance of the use of bridges in the troughing, as advocated on page 318 (although small asphalt bridges were used to ensure the bitumen getting under the cable), and secondly, as mentioned on page 331, in order to insulate the lead sheath from earth so as to prevent electrolysis. Both the lead sheath and the armouring of each cable are connected to earth at the end terminal boxes in generating and sub-stations and at the intermediate terminal boxes in two large disconnecting chambers along the route. A third reason for the choice of a plastic troughing was to counteract vibration. It may here be

* *Proceedings of the Institution of Electrical Engineers*, vol. 36, p. 153, 1906.

Mr. Smith. pointed out that the description of Howard asphalt troughing on page 318 is not quite correct. It is not a steel trough lined with asphalt, but an asphalt trough protected during handling and laying by an outer trough of thin sheet-steel which serves very much the same purpose as the centreing of an arch, and is not necessary for the strength or stability of the troughing after it is once laid. The principle of this troughing is that the cable should as nearly as possible fit it, that Trinidad bitumen should be used just to cover the cable and that the rest of the filling should be a much cheaper asphalt concrete.

At a test made yesterday (March 8th) on the only length of cable that is available, some 300 yards of route which has been out of service for three or four years, it was found that the resistance between the sheath and earth through the Howard troughing was 2,000 ohms, which, of course, would be sufficient to prevent any electrolysis by stray currents. The joints are of the type shown in Fig. 12, with the exception that as the finished joint has to fit into the troughing all the cores are brought out one over the other in one vertical plane. The lead sheath enclosing the joint, filled in with fluid compound, is a good deal higher than the rest of the level of the troughing, and is simply covered over by a piece of inverted trough. The joints in each core are of the ferrule type, insulated with loose pieces of mica and paper alternately, and then each joint and the whole taped over. I should like to point out that the fact that each core, or rather the two upper cores, are slightly looped upwards at each joint might, if exaggerated, form a useful expansion joint very much in the same way that a steam-pipe bend makes an expansion joint. As far as I know, the method of laying 3-core cables solid in troughing is the only one which demands a joint of practically the same width as the cable itself, since where many cables are laid side by side each joint must fit into the troughing. This joint has the great advantage of the same continuous support from the troughing which the rest of the cable receives. In railway work, where the width of a cable trench is restricted, the fact that very satisfactory joints can be made in a manner which keeps the over-all width occupied in the trench exactly the same throughout may be a matter of very serious importance. This is particularly the case where cables have for any reason to be laid in long culverts necessitating cable joints in the culverts, but more especially where, after cables have been laid on the boundary of the railway, that boundary is afterwards extended and a culvert has to be built over the cables, which is, as a rule, far cheaper than taking up and relaying the cables. These cables, which were all laid by Messrs. Siemens five years ago, have given absolutely no trouble. They have never yet, however, been overloaded in the manner suggested in the paper. There are 600 joints, only one of which failed during the contractor's period of maintenance, and not one of them has failed since. The cables cross under the lines twenty-seven times—in some cases under the whole of the main lines going out of Paddington, while for a good part of their length they are laid in

the 6-ft. way on the top of brick arching, the troughing resting just on the crown of the arches. In that part of the route there are nine bridges along which the cables are laid, and between the end of the concrete bed in the trench and the bridge structure they are laid up a sloped steel plate about 10 ft. long, fixed to the edge of the bridge and anchored into the concrete with a space beyond the anchor left free for bending. This flexible support was intended to distribute and damp down the effects of vibration, and it has been perfectly successful, no failure of any sort having occurred on these slopes. The only trouble that has happened on bridges is that in the middle of the span of some of them the cable troughs have splayed out sideways both sides of the centre line. Whether this is due to expansion from heat, or whether it is due to an effect of vibration with nodes at the ends of the bridges and the maximum amplitude at the centre of the span, I do not know, but it has caused no inconvenience. All high-tension cables were twice tested at the maker's works during manufacture to 20,000 volts, once in water before sheathing and once dry after sheathing. After laying, every length of cable was tested to 12,000 volts alternating for 15 minutes, and it is interesting as showing what careful supervision and good workmanship in the way of jointing can accomplish, that no length of cable broke down under the tests on site. I thought it might be of interest to mention the cost of maintenance within the last four years, that this small system, all laid on one method, and working at 6,500 volts, has entailed. For one year the cables were under the contractor's maintenance. In 1907 the maintenance of the 37 miles of high-tension feeder cables only cost £9; in 1908 it cost £30, largely due to the purchase of a tar boiler; in 1909 it cost £17; and in 1910 £18 10s. The average per annum for the 37 miles is £18 12s. For the whole 51 miles the average has been £41, of which by far the greatest proportion is for the telephone cables. One inspector divides his time between the maintenance of the 50 miles of cable and 10 miles of single track electrified with positive and negative conductor rails. For the latter maintenance, where jumper cable connections bridging gaps in the conductor rails have frequently to be altered, he has the assistance of a jointer, but the time which he can spare from patrolling and inspecting the electrified track is sufficient for the maintenance of the whole of the cables outside buildings. A good deal has been said about the difficulty and cost of laying cables solid, but I think that a system which has never failed in 5 years and has cost less than one-tenth of 1 per cent. of its capital cost for annual maintenance proves that the difficulties can be overcome and that the expenditure is justified.

Mr. Smith.

Mr. W. M. MORDEY: The author, in referring to the question of external damage, expanded what is said at page 320 in the paper about the leakage of steam and hot water causing cable breakdowns. I understood him to add that he found cables in hot places very liable to break down, and that he wondered why. I suggest that it may be simply because the resistance of dielectrics goes down very consider-

Mr. Mordey.

Mr. Mordey. ably with rise of temperature, and that therefore a cable will break down at a lower voltage if the temperature is raised. I should expect a rise of no more than 50° or 60° C. would cause a very serious drop in the insulation.

Mr. Howell. Mr. A. Howell: There are one or two points I would like to direct attention to, first of all with regard to the solid system. The author points out that if is a very expensive system. I think the reason for that is that concrete is proposed. I do not think, with the many excellent forms of ducts or conduits that are now on the market, it is essential to use concrete. We all know that concrete is very expensive when put down in such large quantities and when it has to be laid over any great distance. If the use of concrete is adopted in order to give an extra wall between the various ways to protect the other cables against a faulty one, I think the makers would be prepared to thicken up the walls, which are now about ⅛ in. to 1 in. for a much less cost. With regard to manholes, these are always a necessary evil. I venture to suggest that, if they were drained to sewers—which, of course, would have to be surface sewers—and there were many of them, it would be rather an expensive matter. I do not think much draining could be done for less than about £8 or £9 per manhole. I should also like to refer to Figs. 3 and 4 given by the author in connection with the solid system. I notice there that he shows a very robust tile. I should like to ask him whether he has any experience with a tile having a top in the form of a watershed. I think such a tile would give a better resistance than those shown, particularly when a crowbar is driven down upon it. Furthermore, there is a distinct advantage in arranging for a longitudinal channel in the tile, as it permits of the pitch at all times flowing very readily, ensuring the filling of the trough. While on this point I would like to mention that a lot of trouble in the solid system is due to the men trying to fill too great a length at a time. If it was filled in in short lengths, with a tile removed for inspection at, say, 9, 10, or 12 ft. distances, I think there would not be a great deal of difficulty in getting the trough full if proper pitch plugs were used at the ends of the lengths to prevent the pitch going away. The author also goes very fully into the question of armoured cables. Sometimes when one lays armoured cables as a solid system it provokes a great deal of ridicule. The armoured cable is generally looked upon as being a cable which is made to lie direct in the ground; but there are many engineers who will bear me out when I say that an armoured cable laid in a soil of inferior quality or of a chemical nature, or containing other doubtful ingredients, is not the right type of cable to lay. No one would agree to laying armoured cables in a water-logged district, because there is bound to come a time when the outer jute surface will be soaked through; and since the trench becomes a drain for some one else's trench which has been previously opened, it is a very moot point as to whether the armouring of the cable will not come to grief. I think in many instances engineers have laid armoured cables solid for the purpose of gaining advantage from the point of view of handling the cable. In laying an

extensive system of lead-covered cables, if it is to be done properly it requires a great deal of care in actually handling the cable. It is the usual thing, for instance, to see a navvy with great hob-nailed boots walking along the cable when the ganger's back is turned, and there have been some very nasty blows given to cables in that way which have afterwards caused trouble, the reason of which has been difficult to ascertain. There is an advantage in laying armoured cables solid, because we get the benefit of quicker methods of laying the cables; also considerably longer lengths can be laid, and there are in addition all the advantages of the solid system. With regard to the question of joints, I was very pleased to see the author go so fully into that question. From the diagrams he has given and the samples he has shown I think he has brought to light some extremely useful ideas. There are many joints, particularly on the low-tension side (which joints are far more numerous than transmission cable joints), in which I have found from experience that the conductivity of the joints put forward has not been much more than one-tenth of the conductivity of the cable that would occupy the space were there no joints there. If the question of conductivity in jointing is not looked after there will be a considerable increase in the equivalent lengths of the cable where these joints are to be found. There is at the present time a craze for a cheap joint; but I think the time will come when that will be regretted. I think the conductivity of the joint, no matter what system is used, should be at least equal to the conductivity of the cable that would occupy the space were it not there, and certainly it should be within 1 or 2 per cent. of this. Mr. Howell

Communicated: From the author's reply to my remarks concerning the pitching-in of cables on the "solid system," I am afraid that I did not make my meaning sufficiently clear; for of course it would be out of the question to attempt to fill in troughs at such short distances as those to which he understood me to refer. I may say that instances have come under my notice, in which cables have been put down on the solid system, where yards and yards of troughing have never seen but the smallest trace of pitch filling. In such cases only one method could have been used, *i.e.*, putting tiles on long lengths of troughing already containing the cable, filling the earth over, and trusting to the pitch to run in and fill up solid when poured in at one end. This method can still be seen in operation at times. If the troughs are placed in position, their sides packed with earth and the cable laid in, the tiles may be put on in place, leaving one out at, say, every 3 yards for inspection of the pitch, the troughing can be rapidly and certainly filled, the inspection tiles being then put back as the pitch rises, and the earth rammed back. I agree entirely with the author as regards the shrinkage of black compounds in joint boxes or sleeves. This shrinkage is usually understood to take the form of an even surface shrinkage, but for a joint box closed at the top and filled through plug-holes that is not so, and the author's description is the true one. In a proper water-tight box or sleeve viscous compound is the safest thing to use, unless

Mr Howell black compounds can be got to fill up the spaces as effectively as the former one.

Mr Trotter Mr. A. P. TROTTER: The author speaks of two methods of avoiding electrolysis; in the first place, he speaks of earthing the lead sheath at frequent intervals. I am one of those who believe that is wrong. I believe, as two speakers have mentioned, that it should be earthed at certain points. There is no mystery as to where those points are. They should be at the most negative points upon the cable. I am assuming there is a tramway, railway, or very leaky continuous-current supply system in the neighbourhood, otherwise there is no necessity to earth; but if there is a tramway the most negative point or points, such as boosted return feeder points should be found, and earthing should be effected there. If any current has got into the cable it should be let out through a bond. Earthing at frequent points is only tempting the current to get in at other points.

With regard to the question of the protection of the cables, the author speaks of different methods of protection. It appears that the majority of engineers nowadays are adopting the system of protecting cables laid solid in the earth with a creosoted plank 2 in. thick, as wide as may be, in 12-ft. lengths; because if a conscientious navvy with a pick is told to make a hole in the ground he will go through almost anything he can find. But what does trouble him is a 2-in. plank 12 ft. long. He has no suitable tools for cutting it, he finds he cannot shift a whole plank, but he can toss tiles out of his way. It is also a very valuable warning to him. Armoured cable laid direct in the ground seems to be one of the best methods of laying important cables. Other methods may be more suitable for distribution cables, low-pressure cables, and other purposes. The life of an armoured cable is a question of the soil. I hesitated at one time about burying armoured cables in the ground, and I asked an engineer who proposed to lay rather an important cable in that way what his soil was like. He sent me about 10 in. of an armoured cable that had been ten years in the ground on which the whitewash was still visible on the outside. In some soils it is perfectly safe, in other soils it may be necessary to have a certain amount of protection on the outside. In general, I consider that for an important main an armoured cable laid in the ground with a 2-in. creosoted plank on the top of it is about the best way of laying it.

Mr. Beaver Mr. C. BEAVER (*communicated*): I am much interested in the results the author has obtained with his expansion joint-box, but should like to ask whether the breakdowns on cables, apart from the joints, which he states to have been frequent prior to the introduction of his box, were not invariably *near* joints, *i.e.*, where a part of the cable which was free to move was in close proximity to another part in which the movement was limited or restricted. This has always been my experience, and in fact it is difficult to see how the expansion joint can affect or relieve any stresses set up by expansion and contraction of the cable except in its immediate vicinity. The joint is not the seat of the heating, and the breaking of the joint is due to the movement of a

certain length of cable on each side of it. In other words, it is not so much a matter of the relative movement of conductors and box, as of the bodily movement of the cable outside the box. The preventive measures I have hitherto found successful have been to provide a loop of cable in the manhole on each side of the joint-box, so that the box only formed an integral part of the expansion piece. In bad cases, and where space was limited, joints made with tail-end boxes connected across by loops of rubber cable, and free to move on shelves or rails, have been found successful. Such methods are, of course, cumbersome as compared with the author's method, and for this reason I am anxious to hear as to what happens to the cable sheaths in the vicinity of the box. Lead sheaths in particular are easy to expand, but if deformed in the least by such expansion will take a permanent set which will be exaggerated by each successive expansion, and soon become fractured. With regard to the filling of joint-boxes and the author's preference for an oily or viscous compound, it is obvious that compounds of this character will be necessary for joints in which expansion arrangements are provided. For ordinary work there is much to be said in favour of solid compound with fairly high melting-point. With such compound all questions of leakage, which, by the way, are not inconsiderable where cables are run at high current densities, are swept away. On the other hand, it is more difficult to ensure perfect filling of all interstices in the joint and the box. These difficulties are not, however, by any means insuperable. Some time ago I made a wide series of experiments on this box-filling question, including vacuum and pressure methods of filling. As a result of these experiments, I came to the conclusion that the simplest and most certain method was to introduce the compound into the box by means of a funnel screwed into a plug-hole at the highest point of the box. The only precautions thereafter to be observed are that a head of compound is maintained in the funnel at a higher temperature than the compound which is cooling down in the box, and that this condition should be maintained until the compound in the box has cooled down to somewhere near its solidifying point. The action briefly is, that the entrapped air and gas bubbles occluded in the compound escape *via* the funnel, and their place is taken by compound from the funnel. The physical contraction of the compound in the box due to cooling is also compensated for by drawing compound down from the funnel. In this way the boxes can be absolutely and with certainty filled with a compound having such a melting-point that working temperatures do not displace it in any way.

Mr. Beaver.

I should like to say a word on the subject of bridges and the author's preference for glazed earthenware. I prefer unglazed earthenware bridges, because they can easily be obtained of such a quality that they do not depend on glazing for moisture-resisting properties, and the matt surface helps the adhesion of the trough-filling compound. With regard to asphalt bridges and the idea that they become crushed out of shape by the weight of the cables may

Mr. Beaver. say that I have not only kept cables under observation which have been laid on asphalt bridges, but I have experimentally exaggerated the worst conditions by laying steel bars in imitation of cables so as to get not only a great weight per length, but a great concentration of weight owing to small diameter of the steel bar as compared to that of a cable of equal weight per length. I have found no perceptible crushing of the bridges up to a weight of about 8¼ lbs. per bridge. These bridges certainly soften to some extent when the hot filling compound is poured over them, so that possibly any pressing down which the cables receive may be responsible for the idea that the weight of the cable crushes them. They are, of course, much more easily broken in handling than porcelain bridges. I agree with the author that wood bridges should never be used, but I would add that my experience as regards their supposed attack on the lead sheathing of cables is that it is more often a matter of the wood bridge forming an electrolytic path than of simple chemical action due to the products of decay of the wood. With regard to armoured cables laid direct, I quite confirm the author's remarks as to the favourable results as regards preservation in the case of dry, sandy soils. I recently examined some rubber insulated cables which had been laying in sandy soil for the past fifteen years, the steel tape armouring of which was not even tarnished. A layer of well-punned clay is, as the author states, a decided protection to cables in bad soil. With regard to the improved coverings which the author describes as now being used by the North-East Coast power companies, I should like to mention that my firm made lead-covered cables with a coating of vulcanised bitumen over the lead about thirteen years ago for one of our largest railway companies, the object being to afford the lead special chemical protection on account of it being laid in the track ballast. For several years past the Glasgow Corporation have had a certain type of cable sheathed with vulcanised bitumen over a lead covering, and then a second lead covering applied over all. I quite agree with the author that the slight extra expense entailed by special preventive measures of the kind described constitute a good investment.

The laying of cables in chalk or limestone is not a condition commonly met with, but as a matter of interest while on the subject of soils, I would mention that I have found calcium carbide formed as the result of a cable breakdown where a comparatively large arc had occurred. The limestone and the carbonaceous matter from the filling of the cable trough, together with the arc, provided all the conditions necessary for the formation of the carbide, which, of course, when wetted gave off acetylene quite freely. Touching on the question of electrolysis, there is no doubt that continuous bonding and judicious earthing of metallic sheaths is a much more definite and controllable method than the alternative of insulating the lead sheath. Unless we treat the lead sheath as a live conductor, and see that it is insulated accordingly, we are always faced with the possibility that a local failure of its protective covering, whatever it may be, may lead to

leakage current passing *out* a limited area. As this entails a high-current density, the consequent local corrosion which may ensue will be very severe, so that failure will be likely to occur before there is a chance of discovering it. No conduit into which water may leak, much less one which will absorb water, can be regarded as a preventive against electrolytic corrosion. Mr. Beaver.

Discussion before the Newcastle Local Section on March 6 and 20, 1911.

Mr. H. G. A. Stedman: I trust Mr. Vernier will not mind enlightening us on one or two points, viz.: No mention is made in the paper of the problems involved in running transmission cables across rivers, docks, etc., as often has to be done. What form of protection for the cables would he recommend, also how long a life should such cables have? A difference of potential frequently exists between the lead sheath of well-earthed cables and the rails of railway lines in the vicinity. What is the explanation of this? Is it likely to cause trouble—the polarity reverses at times? With regard to the vibration troubles, if the author has any samples of faults produced by this I should like to see them. On page 315 it is stated that a covering of tape and braid is a protection against chemical action and electrolysis when applied to the plain lead-covered cables. From experiments made with short lengths of cable it would appear that moisture would be absorbed and held by this covering, and thus its protective properties become negligible. This is borne out by the statements on page 331. What is the best method of distinguishing between Trinidad bitumen and pitch blended with oil? What is the best proportion of the latter to use to give the most durable results as to flexibility? Mr. Stedman.

Mr. C. S. Vesey Brown: I should like to ask one or two questions. First, with regard to the question of switching on 19 miles of cable without any charging device, I may say this is totally opposed to what I may call first principles. There must be something more in connection with this which Mr. Vernier has not mentioned, and I, at least, would not like to switch on high-tension cables for such a distance at anything like 20,000 volts, or even at 5,000 volts. If a cable could be subjected to that treatment without the provision of charging devices to withstand the resultant high pressure it is quite new to me. Would it not be better to provide simple charging devices at a moderate cost with a resulting reduction in the cost of insulation and the knowledge that one had a more certain provision against the risks involved? I am interested to hear of the way in which Mr. Vernier has dealt with the trouble due to the expansion of cables, and, although it appears to be a satisfactory one, I would like to know more about the creeping effect of the tube upon the conductors shown in Fig. 17. Unless these are thoroughly protected from creeping they will undoubtedly tend to buckle the ends of the conductor. Perhaps Mr. Vernier will give some idea of the relative proportions of the tube, braid, and conductor. I Mr. Brown.

Mr. Brown. would further like to know whether the design shown has been worked out by "rule of thumb" or according to a basis of mechanical strength. Regarding the question of the oil syphoning out of the joint, if I remember rightly this had been put down to the alternate expansion and contraction of the cores; but that is new to me, as I have always understood that it is entirely due to a capillary effect of the core insulation. The drying-up of the insulating material inside the cable gives a vacuum which, with the assistance of air leakages along the cores, all help the capillary action. The drying-up of the joint-box insulation is one of the most serious items of underground cable systems. It has generally been held by outsiders that the installation and maintenance of a cable system is a very simple matter, but we know that a cable system requires to be more carefully engineered than even the power house. I remember one of the members of this Institution, who was here many years ago, engineered a cable system in this district (South Shields), perhaps more thoroughly than was necessary, but I believe the greater part of that system is as good to-day as when it was installed. Considerably more time and money was spent on it relatively than the rest of the plant, but the result is undoubtedly in favour of the view that the time and money has been well spent. The present-day practice seems to be to get there as quickly as possible in order to get the customer connected up without thinking of the future maintenance of the cable and system generally.

Mr. Robb. Mr. J. M. ROBB: I have been much interested in Mr. Vernier's remarks regarding subsidences. The most difficult analogous case in the experience of the Post Office is perhaps that of damage to the cable on the Forth Bridge, and in that case there was a variation in length of 5 in. in twelve hours. This was fatal to the first cable, which did not last long. It was replaced by a 76-wire cable in which 8 bights were arranged vertically alongside the fittings of the bridge to take up the movements. For telegraph and telephone cables the Post Office uses the draw-in system exclusively, and the latest example in this part of the country is the completion of the cable between Newcastle and Leeds, which links up Newcastle with London.

I may mention two points of interest in connection with the drawing in of these cables—the use of petroleum jelly in the proportion of about 1 cwt. to a mile of cable. It not only acts as a lubricant, but is claimed to be a protection against electrolysis and chemical action. There is also the use of a petrol-driven motor winch by which five lengths, each of 176 yards, were drawn in daily; whereas the previous record using hand winches was three lengths. The bonding is very important; we go in for it wholesale, and I consider it to be the salvation of our system.

Mr. Sloan. Mr. R. P. SLOAN: On page 333 Mr. Vernier mentions that the movement per mile of cable may amount to 4 ft. 6 in., and I would like to ask if this is taken into account in fixing the position of the cores when cables are being laid in frosty weather in view of the possibility of the cable expanding as the temperature rises.

Mr. C. TURNBULL: I have had some cables laid many years ago with bitumen compound, which seemed very good stuff. Owing to shrinkage in cooling, it went into holes which let water into the joints. Since then viscous compound has been used, and it has been satisfactory. The question of bonding is of perennial interest. I have been content to bond all lead and earth at the station, but this is on a small system only. To earth at other points seems to invite traction currents to enter the lead, especially if the current can by these means get a short cut to the station. Bonding to the water pipes lays one open to claims from the water companies in case of electrolysis. Wood troughing does not appear to be satisfactory, and will probably soon go out of use. Pitch run into troughing on the solid system has sometimes caused trouble when laid down a steep hill, as the pitch slowly creeps downwards and flows out at the bottom. The action may take many years to complete itself, but it seems none the less certain to happen in the end. Has Mr. Vernier had trouble of this kind? The compounding of armoured cables is very important, but it is very difficult to get cable makers to recognise this. Many times cable makers have promised to have the whole mass thoroughly impregnated with compound from the lead to the outer serving, but when the cable has come to hand, this has not been carried out. Makers are, however, gradually improving in this respect. The filling-in of the conductor strands with suitable compound is important as it prevents damage from water creeping along a broken cable. Mr. Turnbull.

Mr. F. O. HUNT: Referring to the figure for current densities on page 323, I would like to ask if this refers to the current density in the joint or in the cores of the cable. In respect to the specially braided joints and the soldering thereof, I would like to know whether these are soldered with any of the fluxes which are very largely advertised, or simply with pure resin, and whether these fluxes are really as free from corrosive action as they are advertised to be. I have experienced difficulty in managing to prevent workmen from using fluxes which are liable to set up corrosion. With regard to vermin eating the lead pipes, I think that they do this simply because they want to get at something at the other side. I remember a case in which it was very obvious that the rats wished to get at something on the other side of a gas pipe, and their destructive capabilities caused a leak of gas which in turn nearly caused an explosion. With regard to the breakdown of cables following surges some time after the surge has occurred, I would like to know whether it is not probably the case that a succession of surges produces cumulative damage which in time results in the breakdown on a comparatively small surge. In the case of the switching-in of long cables, opinions differ as to whether it is safe or not. Probably it would be well to test the voltage effects with an oscillograph; and if this revealed nothing serious, there would seem to be no need for charging devices. The factor of safety for cables was given by Mr. Vernier as 10 to 20. This would mean that Mr. Vernier's cables would stand from 200,000 to 400,000 volts, at any rate for an instant. This seems to be a very high figure. Mr. Hunt.

Mr. Johnson.

Mr. T. B. JOHNSON: In reference to Fig. 2 on page 315, I would like to point out that where the number of cables is small it is better to lead the pipes in and out at the side of the manhole than in the middle of it. The cables can thus be run straight, instead of being spread out at each side as shown in the diagram. Space is provided for working at the cables or for making Y joints, and the cables are readily supported on the side of the manhole. With regard to the question of draining manholes to sewers, I would suggest that in all cases where this is not done a sump hole should be provided. This is readily obtained by sinking a 2-ft. length of 9-in. earthenware pipe, so that the top edge of the socket is level with the floor of the manhole. The bottom of this pipe should be filled to a depth of 6 in. with concrete, with a top layer of cement mortar ½ in. thick. In boxes and manholes where trouble is experienced owing to street-cleansing operations (or heavy rains), we have found it advantageous to caulk the covers tightly into the frames with tarred yarn and a mixture of crane grease and whiting. Mr. Vernier seems to think that bitumen is quite satisfactory for the solid system, but some years ago Mr. James Perry pointed out that bitumen does not adhere to lead, and tends to crack under vibration, thus forming a path for air and moisture. He suggested that it was advantageous to lay cables in sand moistened with coal-tar, which presses firmly about the lead, thus excluding air and moisture. I should like to hear whether Mr. Vernier has had any experience with this method.

Mr. Vernier refers to armoured cables. Our experience with these was very unhappy. Cables with double steel ribbon were tried, but as soon as cross-roads and streets began to be formed, these cables suffered from subsidences, and the results were disastrous. The insulation could not be kept up, and we now use the draw-in system, even along country roads.

Mr. Morton.

Mr. W. R. MORTON: Referring to the statement on page 315 that taped and braided lead-covered cables should be used for draw-in work on the ground that protection from electrolysis is afforded, this might delay electrolytic action, but given right conditions—*i.e.*, wet ducts and leakage currents—the ultimate condition will probably be worse than with plain lead-covered. These fibrous coverings eventually become soaked with water, so that the cable is continuously surrounded by a sort of wet blanket, which prevents anything in the way of a flow of water, and is calculated to retain in place any deleterious chemicals. In addition they are extremely difficult to pull out after a few years' service, as the compound with which the braids are served sticks to the conduit. I remember actually breaking the conductor of a 37/15 jute-served cable that had been laid for about two years in vain endeavours to pull it out. With regard to asphalt troughing, I have laid a good deal of this. Its chief disadvantage is not in its qualities so much as its price, which, even when care is taken not to waste the filling materials, is a few per cent. above the cost of wood troughing. It gives a structure which is homogeneous and continuous, the joints

Mr. Morton.

being welded. It is also slightly flexible, and for this reason suitable for such positions as are subject to vibrations. It was used, I believe, for the trunk feeders of one of the electrified railways in London (G.W.R.). In addition it runs very much cooler than either wood troughing, earthenware troughing, or cables drawn in pipes, an important point where cables are run at a high-current density. Ordinary armoured cable laid direct runs a few degrees cooler, though probably the bitumen sheath used by Mr. Vernier over the lead on his armoured cable would nullify this difference. With regard to the expansion of conductors due to heat, I believe Mr. Harold Gray, of Accrington, introduced and used with success a device to take care of this expansion. It simply consists in leaving out one or more of the strands in each layer so that room is afforded for the individual wires to move transversely. On expansion occurring, each wire instead of thrusting itself out at the far end takes a slightly wavy form about its own axis, the expansion thus being taken up without lengthening the cable as a whole. Of course, this is no use as a protection against subsidence. I have seen several arrangements designed to cope with expansion and subsidence, but I think Mr. Vernier's is the only one that is both simple and effective. With reference to joint-box compounds, these all possess a high coefficient of expansion, and this not only accounts for the difficulty in filling boxes, but probably accounts for many a case of what is usually called leakage. A cable running warm causes this compound to expand if this is possible, and probably the absorption of oil mentioned by Mr. Vernier is due to this, rather than to leakage or absorption up the cores, any air present in the cores taking the place in the box of the excluded oil when the cable cools down. I should like to hear from Mr. Vernier about his fault-finding experiences. I imagine the "Merz-Price" protection must help him a good deal by providing "clean" faults. A fault on a cable carrying a large power generally results in about half a yard of cable being reduced to a mass of melted copper, lead, iron, and carbon, this throws out of truth the usual fall of potential methods of location. If I am right, it must be a great boon to the mains engineer. On the other hand, it may be that it cuts out a cable which is leaking, say due to damp paper, from one phase before an actual breakdown has occurred, in which case a high-resistance fault has to be found. Again, referring to the use of braided lead-covered cable for solid work with the object of making the filling compound adhere more closely, it is my experience that compound adheres no better to damp braidings than to damp lead. As a braiding, no matter how well served, is bound to take up and retain more moisture on exposure to rain than a plain lead-covered cable, which dries quickly, it appears to me that the risk of trouble is even greater than with a plain lead-covered cable. I would like to mention a form of steel-tape armouring lately introduced, which consists of rolling an arch-shaped rib in the middle of the inner strip. This ensures that the two tapes are maintained in correct position, the one covering the joint, and, of course, strengthening by reason of the shape of the rib the portion left unprotected by the outer strip.

Mr. Morton.

I entirely agree with Mr. Vernier that to attempt to insulate the lead sheath from earth as a preventative of electrolysis is not likely to be successful. My own experience is that discriminate as distinguished from indiscriminate earthing of the lead sheath—which, of course, must be electrically continuous—is the best thing. The danger-points on tramway systems can usually be located—such as the neighbourhood of negative feeding-points and cable runs that may short circuit the rail return path—and the connecting of the sheaths to efficient earth-plates at such points helps a good deal. Referring to the value of a bitumen sheath as a protection against electrolysis, mentioned at the bottom of page 321, this will undoubtedly delay the commencement of electrolytic action, but cannot be regarded as an absolute preventative. The fibrous coverings of this sheath themselves become in wet ground a vehicle for electrolysis. The result is that alkalies are set free on the surface of the bitumen sheath. These alkalies attack the bitumen and rapidly penetrate it. The appearance of bitumen which has been so attacked is very similar to a lead sheath corroded by electrolysis. If bitumen were not subject to this effect, it would probably provide the ideal sheath asked for in the last paragraph of the paper, as its mechanical weakness could be allowed for by providing suitable external coverings. I also would like to correct a misunderstanding with reference to the sheet iron formerly used with asphalt troughing. This is merely a former and is used simply as such; it is expected to corrode away, and is in no sense a support for the trough. It is interesting to note that a cable laid in asphalt trough without this iron sheet runs cooler than when the sheath is in place. This is probably due to the fact that a film of air is enclosed between the asphalt and the iron. With reference to the stresses set up in a cable by subsidence, I would like to ask Mr. Vernier if he does not think that the spiral steel strip armour he had adopted is partially, if not wholly, responsible for the freedom from trouble that these cables have experienced. G.I. steel strip has a breaking stress of about 30 tons per square inch, and the cross-section on a cable of the size used would be probably between 1 sq. in. and 1½ sq. in., so that before any strain can have any effect on the insulation or the copper, the armour must either stretch or break down. These cables are only buried 2' ft. deep, and it seems to be extremely unlikely that a subsidence will give rise to such a stress. It is more likely that the cable will cut through the filled-in earth and so relieve the stress.

Mr Hunter

Mr. P. V. HUNTER: To my mind the most important statements of fact in Mr. Vernier's paper are, that the mains system represents approximately 50 per cent. of the capital expenditure of an undertaking, and that mistakes are costly. These statements settle the whole policy of the design of laying and maintenance of transmission cables, and properly considered will lead to a conservative policy in which nothing is left to chance. During the last five or six years I have had an opportunity of discussing with Mr. Vernier the various troubles and defects as they have arisen, and the methods of over-

coming them, and it is perhaps not surprising that there is very little, if anything, in his paper to which I take exception; in fact, in one or two matters I feel inclined to go further than he does. Undoubtedly the most important issue raised by Mr. Vernier's paper is the abandonment of the solid system for cables with improved armouring. In so far as Mr. Vernier's paper is concerned the life of a high-tension cable depends entirely on the effectiveness of the surroundings of the lead sheath in preserving it intact. Turning to page 329 of the paper, it will be noted that there are seven general causes of breakdown. So far as external damage and pressure surges are concerned, the solid and armoured systems may be considered as equal. For resisting chemical action, electrolysis, subsidences, overrunning and vibration, it is considered that probably armoured cables have a decided advantage over the solid system. In the case of subsidences and vibration this will, I think, be readily conceded, and it is undoubtedly a fact that an armoured cable when compared with a similar cable laid solid has a much smaller temperature rise for a similar load, and will thus allow of more overrunning. There remain to be considered chemical action and electrolysis; it is for these troubles that the special bitumen compound sheath over the lead is used. The jute coverings ordinarily used on armoured cables offer very little protection against either chemical action or electrolysis as they absorb water very readily, and as Mr. Vernier mentions on page 321, it is probably for this reason that armoured cables were largely abandoned for the solid system in this country. The sheath of bitumen compound used under the jute is therefore relied on for the prevention of electrolysis and chemical action. As it will not absorb the heavy bitumen compound used to protect the cables, there would seem to be no object in using jute in the construction of armoured cables at all, and for some time the proposal of dropping the jute has been seriously considered. The alternative construction which will probably be generally adopted for work in this district is as follows. The lead of the cable will be coated with a sheath of bitumen or compound as before, and afterwards taped over with two tapes previously treated with the compound. A second layer of bitumen compound will be then applied and the armouring wires wound on. After this a further layer of compound will be applied and two more tapes, the cable will then be finished with a last layer of compound and lime-washed. The effectiveness of such a cable, of course, depends entirely upon the bitumen compound, and this should be just plastic at ordinary temperatures. If an examination is made of the coverings of a cable made in this manner, it will be found practically impossible to remove them, the whole being cemented together by the compound in a very tenacious and solid manner. Another important point is that with a covering of this description, while the lead sheath has a maximum protection, the armouring is also protected by compound. Mr. Hunter.

Mr. Vernier mentions on page 334 of the paper that all cables of the system are switched "off" and "on" without any charging devices.

Mr. Hunter. The reason for this is that none have been found necessary. In reference to Mr. Vesey Brown's point I would say that a more expensive construction of cable has certainly not been adopted on account of this switching. One point to remember in this connection, of course, is that the system is supplied exclusively by a turbine-driven plant and the voltage wave approximates very closely to a sine curve. Under these conditions mathematicians appear to agree that a surge, on switching-in will not exceed twice the normal pressure. Another point is that the higher the working voltage of the cable the lower the capacity per mile. In case it may be of interest, I mention the figures for inductive capacity for 1,000 yards measured between one core and the other two and lead sheath for 0·1 sq. in. 3-core cable constructed for various voltages:—

3,000	volts	...	0·28	microfarads	for 1,000 yards.
6,000	,,	...	0·22	,,	,, ,,
12,000	,,	...	0·18	,,	,, ,,
20,000	,,	...	0·13	,,	,, ,,

The figures are taken from a cable contract with Messrs. Callenders, and may be regarded as typical. An explanation that cables will stand enormous pressures momentarily will, I think, be readily understood when the fact is thoroughly grasped that the breakdown of insulation is largely a question of heating of the dielectric. An ordinarily constructed 20,000-volt cable will not break down at 100,000 volts (with the working periodicity) for some time. The ultimate breakdown is due to the temperature of the dielectric gradually rising, by reason of the losses in the dielectric, until the temperature reaches a point at which the dielectric becomes a conductor and breaks down. A surge has to be of sufficiently high voltage to break down the dielectric at ordinary temperatures, since it only lasts for a fraction of a second, and can therefore have no appreciable effect in raising the temperature of the dielectric.

The next bogie which Mr. Vernier exposes, and to which I propose to refer, is the question of creosote. The objection to impregnating wooden troughing with creosote has been proved to be unfounded; as a matter of fact, there are 20 or 30 miles of cable laid in creosoted troughing in this district which has been in the ground for five or six years without any harmful action. Since creosoting is the only satisfactory treatment for wood buried underground, it is unfortunate that cable manufacturers held out against its use so long. I should also like to mention the expansion joint described by Mr. Vernier on page 332, and shown in Fig. 17. The troubles which led Mr. Vernier to design this joint were very serious, and on one particular route, namely, the 20,000-volt cable laid between Birtley and Pelton sub-stations, it was practically impossible to keep the cable in service for more than a week or two together on account of failure of joints due

were found broken down at the same time. Since the expansion joints were installed breakdowns have entirely ceased, although there is still a considerable movement of the earth along the route of the cable. I think nothing more than this need be said in support of the joint. Mr. Hunter.

There are no other main points in the paper with which I propose to deal, but there are a few notes which I have made here and there, and to which I would like to refer. On page 315 Mr. Vernier gives as a reason for not having more than two pipes in the width of a duct line the fact that there is a difficulty in dealing with the bend from the middle pipes in manholes. Another important reason is temperature rise. With more than two pipes the temperature of the cables in the middle line of ducts is apt to get high, and since the factor of safety of the cable for a given pressure decreases with increasing temperature, the current density of the cables in the middle of the duct line would have to be limited. The manhole shown in Fig. 2 is that adopted on the duct lines in connection with the cables crossing the river through the special tunnel at the Carville power station, and the arrangement certainly works very satisfactorily in practice. The principal objection is the additional concrete required where the pipes are splayed out as they approach the manhole. On page 318 Mr. Vernier says that Trinidad bitumen is superior to pitch for cable laying on the solid system. This is true, but it must not be overlooked that coal-gas has a very serious action on bitumen. On the same page Mr. Vernier refers to the evaporation of the thinning oil from pitch, the effect being accelerated if the pitch is exposed to the air. This is also true of vulcanised bitumen, and may readily be seen from the two samples shown, one of which shows how the oil has evaporated from the vulcanised bitumen covering of a cable drawn into a duct line where the air has access. The other sample is of a vulcanised bitumen, which has been laid solid for the same period. In this case the bitumen is as good as when it was first laid. The chemical action of wood bridges on the lead sheath of a cable, referred to on the same page, may be greatly accelerated by weak electrolysis, that is to say, a current so weak as ordinarily to be negligible. On page 319 Mr. Vernier refers to the fact that pitch does not always adhere to the plain lead covering of cables. I have not seen so much cable opened up as Mr. Vernier, but speaking of what I have seen I should say that it hardly ever adheres properly to the lead covering, and not at all in the sense that glue adheres to a piece of wood. In connection with the protecting cover of armoured cables on page 320, it is at first sight perhaps not clear why tiles should be preferred on the solid system and a wooden cover for armoured cables; the difference, however, is that, in the case of the solid system the tiles are directly on top of the trough, and any one disturbing them immediately exposes the troughing. In the case of the armoured cables there is 3 in. of earth between the cover and the cable, and tiles might be readily removed without the excavator being aware of the presence of the cable. I think every one will agree respecting the superiority of the method of jointing the cores of

Mr. Hunter.

the cable by flexible braids shown in Figs. 10 and 11. In a coal-pit, where solder cannot be used, its advantage is obvious. As regards jointing, I have no hesitation in predicting that the joint filled with soft compound after it has been exhausted by a vacuum pump will become universal for high-pressure systems. Any one who has had experience of the trouble encountered with joints on high-tension cables, practically all of which is attributable to air or moisture, will certainly agree with this view. I may mention that one important advantage of the system is that the vacuum very thoroughly tests the workmanship of the jointer in plumbing the lead box, and this ensures that no moisture will have access to the joint or cable due to bad plumbing. An important objection to cast-lead sleeves mentioned on page 329 in connection with Fig. 13 is that they are frequently porous; in fact, it is not possible to employ them in connection with the vacuum joint on this account.

Mr. Fawssett.

Mr. E. FAWSSETT: I am in entire agreement with the author's condemnation of the ordinary lead-covered cable laid solid. Neither of the safeguards against electrolytic corrosion are more than palliatives, as earth-plates can shunt the weak points only and reduce the rate of corrosion, and these are never less than 6 or 7 ohms per pair, usually 10 or more, and they tend to get worse with age. I do not see that it is possible to permanently insulate the lead sheath from earth, as, where there is any movement of the ground, any unyielding system could not remain intact. With reference to the expansion of the lead due to watts lost in the cable, experiments have shown that the lead only reaches about 10 to 15 per cent. of the copper rise, higher figures being obtained if two cables are laid in one trough. For 50° C. rise on the core very high-current densities may be allowed, if the excessive drop does not matter—a 0·0125 sq. in. high-tension 3-core cable may be run up to 6,000 amperes per square inch, a 0·05 at 2,400 amperes per square inch, and a 0·1 sq. in. at 1,900 amperes per square inch.

Professor Thornton.

Professor W. M. THORNTON: With regard to breakdowns taking place some distance from where the short circuit was developed, this is quite simply explained by a mechanical analogy. In Fig. A, A is

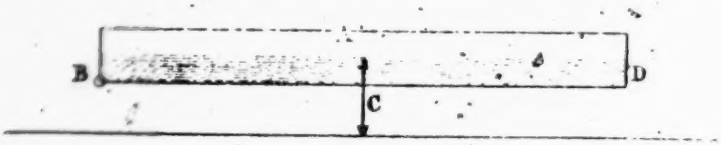

FIG. A.

a trough hinged at B, the distance C representing the voltage of the cable above earth. Imagine the trough filled with water, and the end remote from B suddenly dropped through the distance C; this being analogous to what happens in the event of a cable going to earth at D. If now before the water runs out of the trough it is suddenly elevated up to its original position, it is obvious that a wave of water or electric charge will be reflected with great violence along the length

of the trough towards B, and in the event of the generator voltage being at a maximum at the moment B is reached, an extremely high voltage may result. [Mr. C. FARADAY PROCTOR: From the frequency and other factors of the circuit it should be possible to calculate the distance from the point of the short circuit at which the cable would break down.] I agree that this could be done, but it would not be a simple matter. I believe that the electrical breakdowns in cables in the end are due to the effect of dielectric hysteresis. I should like here to show some oscillograph records of condenser current waves with marked hysteresis, as I believe this is the first dielectric hysteresis loop from a sine voltage. If the dielectric constant of the insulation remains constant the quantity of the charge is strictly proportional to the volts, and when the voltage falls part of the charge is left behind, which eventually falls, but lags behind the voltage. The cable breaks down in the same way as any other condenser. Plotting current values in the condenser against time we get a curve rising slowly in a straight line up to a certain point and then rapidly increasing, and this behaviour is characteristic of every type of condenser, except perhaps one made with mica. If the maximum point in the hysteresis loop is well on the way towards the yield-point in the case of an alternating-current circuit the maximum point is progressive, and there is a creep of hysteresis as well as of the quantity. This idea is based on Foster's theory of the breakdown of metals under repeated alternating stresses, and there appears to be a complete analogy between the electrical and mechanical actions. [Mr. P. V. HUNTER: This creep will account for direct-current cables standing so much better than alternating-current cables.] Yes; but under direct stress there is a more extended effect. Plotting the dielectric constant against time, however short the period, there is a given value for K. After the first charge the polarisation proceeds automatically. On discharging by short-circuiting there is first a sudden drop, and the charge then comes out at the rate at which it went in. All we have to do is to start the yield, and the polarisation increases automatically, so that, under voltage, there is reached a polarisation which is the same before all voltage gradients. We might expect from this that direct-current cables would break down more easily than alternating current. That they do not shows that the breakdown is due in alternating-current cables to a cumulative yield of the nature suggested, the strain creeping towards the end with great rapidity. Professor Thornton

Mr. G. B. BURROWS: In regard to expansion joints the author has shown that in districts such as this breakdowns and serious interruptions of supply are inevitable unless discriminate use is made of some type of flexible—not expansion—joint. Four years ago I was faced with subsidence troubles which it was imperative to overcome, and it resulted—by co-operation with a fellow engineer—in the design of a flexible joint-box, the manufacture of which was taken up by Messrs. Callenders. The Bowden wire action was noticed by us, hence we used plumbed glands; experience has justified their use, as in one instance Mr. Burrows

Mr Burrows.

only, out of thirty-two such faults, have I found the lead of the cable appreciably thinned near the gland, this actual subsidence occurring within a few yards of the joint, and the thickness of the sheath was reduced from 0·17 to 0·121 in., the cable being 0·3 sq. in. 3-core high-tension wire-armoured paper-insulated. The box as originally designed allowed for a maximum expansion of 9 in., but they were so jointed up as to allow an initial pull of 7 in. or a compression of 2 in., the accommodation of which is fulfilled admirably. The main points about the box are :—

High insulation.
Ease of inspection.
Allows of disconnecting for testing purposes.
No sliding contacts.
Accommodates expansion and contraction.
Three years' hard service without a single failure.

Owing to unavoidable circumstances only six or seven are in use to date, but on one feeder section where three only are installed (the bad ground covering an area of 200 yards), faults due to subsidences were almost fortnightly occurrences previous to the adoption of this box, whereas not one failure has occurred since their installation three years ago.

Mr. Drummond.

Mr. A. L. E. DRUMMOND: All our cables are in iron pipes or conduits, and fortunately we have no trouble due to movement of the ground. Also as the currents carried are much too small to cause heating of the cores the temperature tends to remain constant.

Mr. Viall.

Mr. H. R. VIALL: I have listened with much interest to the particulars which we have heard regarding the new type of bitumen-sheathed cables, but it seems to me that there is a danger of the bitumen sheath becoming plastic and allowing the cable to sink, thus reducing the factor of safety on the underside of the cable. The flexible joint described by Mr. Burrows is also very interesting, but the cost would appear to be prohibitive.

Mr Clothier.

Mr. H. W. CLOTHIER: With regard to pressure surges and the installation of cable-charging devices, Mr. Vernier says it is surprising to him to learn that cable-charging devices are still in use. It may be of further interest to him to hear that they are included even now in some specifications, much to the inconvenience of manufacturers who try to simplify switchgear as much as possible. Considered from a mechanical point of view, the introduction of auxiliary bus-bars and interconnections is very difficult to deal with satisfactorily, and I hope that the points brought forward in Mr. Vernier's paper may help to eliminate this complication in the future. The idea in installing cable-charging devices is to prevent an excessive pressure rise on an open-circuited cable when switching-in, such excess pressure being caused by oscillations which occur when there is a certain relation between the capacity of the cable and the inductance of the

machine in series with the cable. I believe it was proved many years ago that the phenomenon was more serious in cases where the machines had an irregular wave-form; in a bad case the pressure rise amounting to about three times the normal. Even in such extreme cases, however, it is questionable whether cable-charging gear is any use. It must be remembered that the increase of pressure is only of momentary duration, whilst cables and apparatus are always tested to double their working pressure, and sometimes three times the working pressure, for several minutes. No part of the system could stand its normal voltage continuously if it were unable to withstand a momentary pressure rise such as might be occasioned by switching-in an open-circuited cable without a cable-charging device. We have also to remember that a similar phenomenon may result from other operations than switching-in; for instance, the occurrence of a heavy short circuit, which is suddenly cut out, has the same effect on other parts of the system as switching-in, and the cable device cannot be put into commission in such cases. The correct policy, therefore, seems to be to insulate the system throughout with a fair margin of safety and to dispense with the cable-charging device. It seems to me that excess current-surges, such as are occasioned by a short circuit, are more to be feared, in that they make the conductors writhe out of shape in a way likely to damage some part of the insulation so that it breaks down sooner or later. Mr. Clothier.

Mr. H. Bridges: Referring to the draw-in system, Mr. Vernier suggests that the arrangements of pipes in manholes, as shown in Fig. 2, page 315, is preferable to the arrangement shown in Fig. 1, on account of neatness and safety from falling covers. As regards the danger of manhole covers falling on the cables, this can be easily avoided by having the pit made longer and wider than the manhole cover, so that if a cover should fall, even with the arrangement of cables as in Fig. 1, it would drop clear of the cables. Mr. Vernier mentions that unsupported bends should be avoided. In my opinion, the distance from the end of the pipe to the first cleat should not be more than 4 ft. for large cables, and for smaller cables this distance should be shorter. The arrangement in Fig. 1 has many advantages which are not obtained in Fig. 2. In designing manholes there are other questions to be considered besides neatness and safety. One important point which appears to have been overlooked, is that after the pipes are laid and the manholes built, the cables have to be drawn into the pipes. If the arrangement of pipes is such that the work of drawing-in cables is going to be greatly increased, then it has been badly designed. The pipes and manhole should be arranged so that the least possible labour is required in drawing in the cables. The arrangement in Fig. 1 gives better facilities for drawing-in cables; this is one reason, and I think a practical one, why the arrangement in Fig. 1 is preferable to Fig. 2. I am afraid these are points which are often overlooked in the laying of pipes and building of manholes. The pipes should be arranged so that as near as possible a Mr. Bridges.

Mr. Bridges. straight pull can be obtained in drawing-in cables, as it is obvious that if the pull has to be exerted round the edge of a pipe the friction is being added to, and therefore extra labour must be obtained to carry out the work, which means, of course, extra expense. Then again, if the cable breaks down, it is necessary to have the cable drawn out as quickly as possible. I have known cases where it has taken all day before it has been possible to draw out a length of cable owing to the pipes having been arranged in such a position that it was impossible to get a straight pull on the cable, nearly all the energy being spent upon drawing the cable round the pipe end. The pipes are generally laid and manholes built by one department, and the mains department have the privilege of drawing in the cables as best they can. Then again, with reference to the expansion and contraction of cables, Mr. Vernier states that with an increased temperature of 90° F. the conductors will expand 4 ft. 6 in. per mile and the lead 7 ft. 6 in. If this is the case, the arrangement in Fig. 1 is an advantage over Fig. 2, as these bends would take up the movement of expansion and contraction. In my opinion a coffin-shaped manhole would be the best, as the advantage of both arrangements would be obtained. In the laying of armoured cables in the ground, Mr. Vernier states on page 321, that on the Continent it is the practice to surround them with sand. This would, no doubt, add to the cost of laying, but it occurs to me that it would be an advantage in districts where subsidences are known to exist, as it would give the cable much more freedom to move, since the friction on the cable from the surrounding soil would not be so great as if the cable were surrounded with sand.

Mr. Harris. Mr. T. H. HARRIS: It is interesting to notice that after such a long trial the solid system has been abandoned, but I think the reasons stated are sufficient. The armouring which Mr. Hunter has described is exceedingly good. A cable which we are laying at present has a bitumen sheath, which does adhere to lead. The best protection for this type of cable is a wooden board, but this must be well creosoted. If it was proposed to run cable at 150° F. a lot of difficulties would be likely to crop up, since tape at this temperature changes its dielectric properties. Fig. 12 shows the type of joint which has been used for a number of years. It involves a lot of handling by the jointer, with consequent danger of moisture from his hands, and necessitated the tapes being boiled in oil, etc., on the spot. Fig. 13 eliminated the work of the jointer to a very great extent, but employed stars to spread the cores; these are weak points in any joint. Perhaps I might mention the type of joint we have recently introduced for extra-high-tension work (30,000 volts). It consists, essentially, of impregnated paper cylinders to insulate the ferrules and of a lead sleeve plumbed to the sheath of the cable. The sleeve is filled with compound of the consistency of vaseline when cold but very liquid when hot. The exclusion of all air and moisture is secured by exhausting the sleeve—prior to introducing the compound—by means of a petrol-driven air-pump, which is made very compact and portable to render transport easy. A

very high degree of vacuum is thus obtained and all moisture is got rid of by heating the sleeve whilst the pump is working. The compound, when poured into the joint, so treated is able to flood the inside of the sleeve, neither moisture nor air being present. I have never met a high-tension joint which could be condemned on the point of workmanship. Some breakdowns have been of a novel character. One joint made as in Fig. 13 had been filled with about 35 lbs. of compound. Upon opening it, it was found that the whole of the compound had disappeared: the insulating tape had also disappeared, indicating that the joint had been subjected to a very high temperature. In another case, upon opening the joint, we found that not only had the compound disappeared, but the pitch with which the joint was surrounded had leaked into the sleeve and had taken the place of the compound. The compound had evidently been previously destroyed, as in the first case. This was a 20,000-volt joint and had run for some time quite satisfactorily at that pressure, though only insulated with pitch. It may be of interest to note that we used to make these joints with tape and mica interleaved, but later decided to leave out the mica. I am not sure, however, that that was a move in the right direction, as although the tape with mica might afford less resistance to perforation at low temperature, at high temperature they both together gave decidedly better results. This indicates that all tests and joints should be carried out at the highest temperature at which the cable will be run. Mr. Harris.

Mr. G. L. PORTER: I did not intend to join in this discussion, but a remark of Mr. Clothier's made me wish to add something. He stated that clearing a heavy short circuit gives the same effect as switching in a length of cable. Recently it has been shown by the oscillograph that an oil-break switch does not by any means necessarily break the current at zero-point, and any sudden break in the current in a cable causes the energy in the circuit to oscillate between the electromagnetic and electrostatic states until it is dissipated. In a line composed of a length of overhead line in series with a short length of cable, on breaking circuit the cable has to absorb all the energy from the overhead line. As, however, the capacity of a short cable is small, high pressures result. With regard to the question of troughing, I had some experience of railway signal work and remember one case where plain rubber cables had been installed in plain wood-casing laid in ballast, but, of course, this did not last long, and when lifted the rubber and casing were found to be almost destroyed. With regard to the question of pressure testing, at one time in the regulations of the supply company it was stated that a length of cable or a choking coil had to be inserted in the low-tension side of the testing circuit in order to prevent an undue rush of current in the event of the testing apparatus breaking down. I found, however, when testing the sparking distance with horn arresters, the choke coil completely altered the shape of the wave with the result that the maximum value for a given R.M.S. value was altered. Without the choke coil it was found that 9,500 volts were required to spark across a given distance, whilst with Mr. Porter.

Mr. Porter.

the choke coil in circuit only 8,000 volts were required to break down the same gap. This experience shows that considerable care is necessary in selecting gear for testing purposes where there is a chance of the wave-shape being altered.

Mr. Addison.

Mr. G. B. ADDISON: Mr. Vernier seems to have come to a very definite conclusion with regard to the solid system and armoured cables; he stated that he did not think the North-East Coast companies would lay any more high-tension cables on the solid system. Armoured cables are nothing new, for I should say they belonged to the methods of the earliest days of laying mains. I cannot speak from experience of armoured cables laid direct in the ground, but I think it is pretty generally admitted that very few engineers speak highly of them who have had such experience. I should prefer a cable laid solid with earthenware troughing, porcelain bridges, and pitch of correct proportions, or if money is no object, bitumen; it makes a more lasting job and offers better protection to the cable. With the improved coverings adopted for armoured cables mentioned on page 321, I think that in waterlogged ground, or where decomposed organic matter exists, these coverings will rapidly deteriorate. My experience of the solid system is that many of its evils are accentuated by carelessness, and the craze for doing it quickly and cheaply. This the author mentions on page 320, and rather excuses it by saying that good workmanship is exceedingly difficult to attain. I have seen good work done, and I go further to state that it can be done with a minimum amount of care. I agree with the author that where earth movements and subsidences are likely to occur, then armoured cables are most suitable. There is a strong point over which I would prefer the solid system to armoured cables laid direct in the ground. When a cable fault develops it invariably bursts the outer covering. If it occurred on an armoured cable laid direct in the ground, and this being waterlogged, one would expect to find much of the cable to be destroyed by water between the two joints. Armoured cables will make the location of faults much more difficult, for cable faults that have come under our notice on the solid system usually burn out and become open-circuited with the insulation sufficiently high to permit of easy location. With armoured cables this would not be the case; the cores would still burn out and open circuit, but would earth also in the wet ground, thus rendering localisation extremely difficult. I would prefer wrought-iron plates put over conduits laid under tramways or roads where concrete is extensively used by the public authorities.

With regard to the expansion joints, I would like to ask Mr. Vernier whether the movement that takes place in his expansion joint is likely to reduce the dielectric strength of the insulation of the cores in the adjacent cable. As was shown, the movement that takes place is not uniform, and from this I should imagine there will be a chafing or rubbing taking place between the cores that may be even sufficient to crack the paper and cause the cores to short circuit. It would appear

that, for subsidences on a large scale expanding cable would be necessary in conjunction with the joints. I congratulate Mr. Vernier on the design of his joint. It is delightfully simple and should prove equally efficient, and meet admirably the conditions it has been designed for. Mr. Addison.

Mr. J. W. Hogg: With regard to the glazed bridges, I would prefer unglazed vitrified bridges, boiled in filling-in compound and allowed to cool before placing in troughing. I quite agree with the author's remarks on solid systems, and that the armoured cable is the most satisfactory for transmission mains, though if laid through made-up ground, etc., I would prefer it laid solid, even with cables such as are now being adopted by the power companies on the North-East Coast which have the mechanical protection sheathed with a bituminous covering, etc. I have had some experience of cable to a similar specification which I first used in connection with the laying of a main through a river bed (which was really nothing more than an open sewer carrying the discharge from dye, bleach, and soap works, in addition to common sewage matter) as far back as 1902, and later, in 1906, I had a similar cable made for laying in the beds of canals in India, in both cases with satisfactory results. With reference to joints, Fig. 15 is a practical joint which is hard to beat over an extended district where one is often in the hands of one's jointers, etc., and knowing this joint to be available, it would require much persuasion to cause me to take up other forms which require highly skilled workmen. As regards the joint compound leaking above the copper core of the cable, I should prefer to have the strand impregnated throughout with a similar compound to that used as joint-filling compound. Regarding subsidences and over-running, I quite appreciate the author's difficulty and the way in which he has attempted to overcome it with expansion joints, and whilst hardly dealing with transmission cables, I would like to mention some of the troubles I have experienced on single feeder cables abroad, of sectional areas of 0·8 sq. in. and over, laid solid and working in a temperature varying from 75° to 100° F. 3 ft. below the ground and at high-current densities. I found it necessary to put in expansion joints to every length of cable and allowed approximately a 3-in. movement each way per 110 yards of a 1·0 sq. in. cable, or 6 in. movement per joint, a 0·5 sq. in. cable being allowed 5 ft. per mile, and after a number of experimental designs evolved one which proved satisfactory, but which could not be used as a disconnecting point; it will, however, be seen that a considerable amount of space is required in the boxes which were designed with reducing-pieces to the troughing and divisions between each joint. Surging, as the author says, is fortunately not common on systems with a high factor of safety, but we must necessarily treat the weakest point in the link when arriving at the actual fact in practice, as those who have had to take up the working of extensive networks quickly realise should the standard of construction have been in any way ing. Mr. Hogg.

Mr Beaver

Mr. C. BEAVER: I am much interested in the results the author has obtained with his expansion joint-box, but should like to ask whether the breakdowns on cables, apart from the joints, which he states to have been frequent prior to the introduction of his box, were not invariably near joints, *i.e.*, where a part of the cable which was free to move was in close proximity to another part in which the movement was limited or restricted. This has always been my experience, and, in fact, it is difficult to see how the expansion joint can affect or relieve any stresses set up by expansion and contraction of the cable except in its immediate vicinity. The joint is not the seat of the heating, and the breaking of the joint is due to the movement of a certain length of cable on each side of it; in other words, it is not so much a matter of the relative movement of conductors and box, as of the bodily movement of the cable outside the box. The preventive measures I have hitherto found successful have been to provide a loop of cable in the manhole on each side of the joint-box, so that the box only formed an integral part of the expansion-piece. In bad cases, and where space was limited, joints made with tail end-boxes connected across by loops of rubber cable, and free to move on shelves or rails have been found successful. Such methods are, of course, cumbersome as compared with the author's method, and for this reason I am anxious to hear as to what happens to the cable sheaths in the vicinity of the box. Lead sheaths, in particular, are easy to expand, but if deformed in the least by such expansion, they will take a permanent set which will be exaggerated by each successive expansion, and soon become fractured. With regard to the filling of joint-boxes and the author's preference for an oily or viscous compound, it is obvious that compounds of this character will be necessary for joints in which expansion arrangements are provided. For ordinary work, there is much to be said in favour of solid compound with fairly high melting-point. With such compound all questions of leakage—which, by the way, are not inconsiderable where cables are run at high-current densities—are swept away. On the other hand, it is more difficult to ensure perfect filling of all interstices in the joint and the box. These difficulties are not, however, by any means insuperable. Some time ago I made a wide series of experiments on this box-filling question including vacuum and pressure methods of filling. As a result, I came to the conclusion that the simplest and most certain method was to introduce compound into the box by means of a funnel screwed into a plug-hole at the highest point of the box. The only precautions thereafter to be observed are that a head of compound is maintained in the funnel at a higher temperature than the compound which is cooling down in the box, and that this condition should be maintained until the compound in the box has cooled down to somewhere near its solidifying point. The action briefly is, that the entrapped air and gas bubbles occluded in the compound escape *via* the funnel, and their place is taken by compound from the funnel. The physical contraction of the compound in the box due to cooling is also compensated for by drawing com-

poured down from the funnel. In this way the boxes can be absolutely and with certainty filled with a compound having such a melting-point that working temperatures do not displace it in any way. Mr. Beaver.

I should like to say a word on the subject of bridges and the author's preference for glazed earthenware. I prefer unglazed earthenware bridges, because they can easily be obtained of such a quality that they do not depend on glazing for moisture-resisting properties, and the matt surface helps the adhesion of the trough-filling compound. With regard to asphalt bridges and the idea that they become crushed out of shape by the weight of the cables, I have not only kept cables under observation which have been laid on asphalt bridges, but I have experimentally exaggerated the worst conditions by laying steel bars in imitation of cables so as to get not only a great weight per length, but a great concentration of weight owing to small diameter of the steel bar as compared to that of a cable of equal weight per length. I have found no perceptible crushing of the bridges up to a weight of about 8½ lbs. per bridge. These bridges certainly soften to some extent when the hot filling compound is poured over them, so that possibly any pressing down which the cables receive may be responsible for the idea that the weight of the cable crushes them. They are, of course, much more easily broken in handling than porcelain bridges. I agree with the author that wood bridges should never be used, but I would add that my experience as regards their supposed attack on the lead sheathing of cables is that it is more often a matter of the wood bridge forming an electrolytic path than of simple chemical action due to the products of decay of the wood. So far as armoured cables laid direct are concerned, I quite confirm the author's remarks as to the favourable results as regards preservation in the case of dry, sandy soils. I recently examined some rubber-insulated cables which had been laying in sandy soil for the past fifteen years, the steel tape armouring of which was not even tarnished. A layer of well-punned clay is, as the author states, a decided protection to cables in bad soil. As regards the improved coverings which the author describes as now being used by the North-East Coast power companies, I should like to mention that my firm made lead-covered cables with a coating of vulcanised bitumen over the lead about thirteen years ago for one of our largest railway companies, the object being to afford the lead special chemical protection on account of it being laid in the track ballast. Also, for several years past the Glasgow Corporation have had a certain type of cable sheathed with vulcanised bitumen over a lead covering, and then a second lead covering applied over all. I quite agree with the author that the slight extra expense entailed by special preventive measures of the kind described constitutes a good investment. The laying of cables in chalk or limestone is not a condition commonly met with, but as a matter of interest while on the subject of soils, I would mention that I have found calcium carbide formed as the result of a cable breakdown where a comparatively large arc has occurred. The

Mr. Beaver. limestone and the carbonaceous matter from the filling of the cable trough, together with the arc, provided all the conditions necessary for the formation of the carbide, which, of course, when wetted, gave off acetylene quite freely.

Touching on the question of electrolysis, there is no doubt that continuous bonding and judicious earthing of metallic sheathing is a much more definite and controllable method than the alternative of insulating the lead sheath. Unless the lead sheath is treated as a live conductor, and is insulated accordingly, there is always the possibility that a local failure of its protective covering, whatever it may be, may lead to leakage-current passing *via* a limited area. As this entails a high-current density, the consequent local corrosion which may ensue will be very severe, so that failure will be likely to occur before there is a chance of discovering it. No conduit into which water may leak, much less one which will absorb water, can be regarded as a preventive against electrolytic corrosion.

Mr. Dawson. Mr. J. E. Dawson: With reference to Mr. Vernier's remarks on electrolysis on page 330, and the question of the bonding of all armoured cables and joint-boxes, I may say that although it has now become almost standard practice to bond everything up solid everywhere, it by no means follows that in ordinary low-tension transmission and distribution it is necessary or even advisable to go to this additional expense; the fact of its being generally adopted is, of course, not of itself a proof. I know of several supply undertakings in various parts of the country where everything is bonded up most elaborately, no expense being spared, and yet a good deal of trouble has been experienced with electrolysis: on the other hand, I know of instances where the lead has been broken at every joint and insulated from the joint-box as much as possible (thus omitting to provide any gratuitous earth-return for tramway or other leakage currents), and yet in these instances, which should by all the rules prove examples of how not to do it, there has not been the slightest trouble. At West Hartlepool, where practically the whole of the cables are lead-sheathed steel-taped (triple concentric for distributors and concentric for feeders and singles for neutral-wire feeders) all the cables are laid direct in the ground, the lead and armour is broken at every joint and service connection, the cable where it enters the joint-box being fitted in impregnated wood bushes, and the whole being well smeared over with high-insulation box compound. These cables have now been laid down nearly twelve years, and so far there has not been a single fault due to electrolysis, not, however, because during this period there has been any miraculous freedom from the usual occasional earth-leakages inseparable to ordinary central station supply; on the contrary, there has been just the usual amount of earth currents as might ordinarily be expected, both on our own supply undertaking (principally on consumers' installations) and also on the local tramways. This policy of splitting-up the lead and armour into as many separate lengths as possible, with as much resistance between each length as possible, was not adopted in the first

instance hastily or without the various pros and cons being carefully considered, but was adopted deliberately on the advice of one of the most eminent electrical experts, and although this policy does not happen at the present time to be fashionable, it has none the less in this instance proved a thoroughly sound and efficient one; and bonding, with all its additional expense in material and labour, could not possibly have improved matters, whereas it might possibly have been the means of introducing troubles which have now been avoided, so that it is as well to remember that although there are points in favour of bonding, there are also points against it. It seems to me that by bonding everything up solid we are attempting to provide a competitive earth return circuit for any earth leakage currents, as compared with the local earth and the water companies' mains, and as it can never be of quite as low resistance as the latter, particularly if the neutral wire of the supply is earthed at the generating station on to the water mains, the result will only be that instead of practically no current travelling on the lead of the cable, as would be the case if the lead was broken at every joint, a large proportion of the current, depending, of course, inversely on the resistance of the respective circuits in parallel, will travel along the lead until it reaches some point in close proximity to a water pipe; it will then split up, a large proportion leaving the lead of the cable for the path of lower resistance, thus damaging the cable through the electrolytic action set up, and completing its return circuit to the generating station, *viâ* the water pipes. This action may, of course, very probably occur at several places on the run of the cable; in fact, wherever the resistance of the respective parallel paths —water-pipes and lead of cable—are such that the circuit *viâ* the water-pipes offers the lower resistance. Mr. Dawson

Then there is the question of the current-carrying capacity of the lead bonds, etc., and fusion. I believe that a good deal of the trouble that is put down to electrolysis on bonded systems is not really electrolysis at all, but fusion, as, owing to the low-resistance path provided by the bonding of the cables, in the event of, say, a momentary dead earth, enormous currents may be encouraged to flow along the lead sheathing and across the bonds, arcing and fusing at every loose or imperfect contact on the route, whether it be in the bonding, earthing-plates, or accidental cross-connections with other earthed services, such as gas or water pipes; then afterwards, sooner or later, moisture creeps, and there is another fault which is attributed to electrolysis. A striking instance of the enormous currents that may momentarily travel along the lead sheathing of bonded cables was given by Mr. G. L. Black, of the Glasgow Corporation Electricity Department, before the Glasgow Local Section, January, 1906, who cited a case where, on a fault occurring on a cable some distance away, a lead bond 2 in. × ½ in. in sectional area, of an exposed joint-box near which he happened to be at the time, instantly went off in a puff of smoke, and stated that the current flowing momentarily would probably be between 6,000 and 8,000 amperes. This occurrence also incidentally indicates how

Mr. Dawson. difficult it is really to know when the bonding and earthing is, and is not, in a reliable and efficient condition.

Discussion before the Glasgow Local Section on April 11 and May 16, 1911.

Mr. Mitchell. Mr. R. B. Mitchell: I am surprised to learn that Mr. Vernier advocates the use of cast-iron pipes in duct systems. We, in Glasgow, several years ago made considerable use of cast-iron pipes, and our experience with them was very unfortunate. We found that although the lengths of pipe were bonded together as carefully as possible, and the whole well earthed, it was impossible to keep the lead from disintegrating at points of contact with the iron, and in course of time at these points the lead became quite eaten through. We then gave up the use of cast-iron pipes entirely. Mr. Vernier also advocates cast-iron troughing for solid systems where cost is not a consideration. We have not had good results in the past with these troughings with lead-covered cables. In the old days I think the tendency was to make the iron troughs rather small to save expense, and the consequence was it was not possible to lay the cables in without having them in touch with the troughs at some points. When the insulation of the cable broke down it might be at a considerable distance from the points of contact between the lead and troughing, the lead became alive, arcing took place at all these points, and instead of one fault there were probably several to contend with. As regards filling material, Mr. Vernier prefers to use bitumen rather than pitch, in spite of the fact that the former is 2½ times dearer. In Glasgow we have used pitch for this purpose for over eight years, and have never had any reason to regret it. In all cases where we have had to open up we have found the cables in excellent condition. Recently, however, we have been using not pitch only, but a mixture of pitch and finely powdered whinstone. We find with the mixture a great increase in strength, toughness, and tackiness, as compared with pure pitch and the cost per cubic foot is reduced considerably. I have carried out experiments to find out what would happen with this material if any subsidence or change in the position of the cable took place, and I found it possible to bend a 6-ft. length of this mixture into the form of the letter U, and then bend it back into the same shape in the reverse direction without the least sign of fracture. Passing on to the question of the making and insulating of joints on extra-high-tension cables, I have on the table a model of our latest type of high-tenison joint. Up to the present we have used a type of joint which followed pretty closely Fig. 14 of the paper. In the new type we have discarded the use of tape entirely, using instead a porcelain sleeve divided into three compartments, one for each core of the 3-phase conductor. This sleeve is slipped over the ends of one of the cores to be jointed together. The joints are then made with copper sleeves in the usual way. The porcelain sleeve is then brought over the bare parts and held in place by a flat piece of

porcelain introduced between the conductors. The lead sleeve is then wiped on and filled up with E.H.T. compound. The advantages claimed for this arrangement are: (1) there is no tape used, (2) the conductors do not require to be splayed out to wind tape on, etc.; we found that when they were disturbed in this fashion the paper insulation was apt to crack unless very carefully handled. We made careful experiments to find if the compound entirely filled the compartments enclosing the conductor in the porcelain sleeve, in which the space is very confined, and we found that it did so, although the compound used was a fairly solid one at ordinary temperatures, and that the joint, so far as that was concerned, was a thoroughly reliable one. We have not one working at present, but we hope to have one soon. Mr. Mitchell.

Mr. D. M. MACLEOD (*communicated*): Mr. Vernier on page 333 of his paper refers to the great strains which come upon cable joints where these are at times loaded up to high-current densities, either in cases of emergency or in order to avert the heavy capital expenditure in laying additional cables. He cites the case of a cable laid in the ground and jointed up originally at a temperature of 60° F., pointing out that with a safe increase of temperature of 90° F. the conductors will expand 4 ft. 6 in. per mile. This amount of movement shows the importance of making provision for free movement at all cable joints, apart altogether from considerations of subsidence. It seems to me that the joint patented by Mr. Vernier, while it is a distinct advance on the usual form of straight joint, hardly meets the conditions. I understand that a movement of only 3 in. is provided either in the form of contraction or expansion. On the Clyde Valley's distributing system we have, for the past three years, been making a practice of providing large expansion bands formed in the same manner as the expansion pipes in a steam-pipe range, with an ordinary straight joint at the top of the bend. This bend is surrounded by an ordinary brick pit of ample size, and by this means we are enabled to provide for a movement of several feet. Formerly we suffered very severely from subsidence troubles, but since taking the steps indicated we have had no further trouble from this cause. I might add that in our Carfin district the movements due to subsidence are so great that there is not the slightest doubt that Mr. Vernier's joints would prove entirely inadequate to meet these conditions. Mr. Macleod.

Mr. W. W. LACKIE: I am practically in agreement with all that is in the paper. If there be room, or rather, width of street, by all means let the mains be laid solid. Where there is not width of street the draw-in system has to be reverted to. It is true that breakdowns due to faulty manufacture are very few, but the converse is also the case, that when a fault does occur all evidence of what was the cause of it is burned out. Mr. Vernier is rather contradictory in reference to his draw-in system. He says that with the use of bitumen fibre conduits, on account of the flush joint of these, less space is taken up and a good deal of concrete can be saved. In the next paragraph he says that earthenware pipes provide greater safety because they give Mr. Lackie.

double the thickness of earthenware wall and greater thickness of concrete. In Glasgow we have a nest of 20 ducts 4 × 5 and have no difficulty with them in separating out the cables at the manholes in a safe and neat manner. This is largely due to the shape of the manhole adopted.

In connection with the solid system the tramway department of this city have drawn in some lead-covered cables on which there is a double covering of lead; that is, the cable is first of all lead sheathed in the usual way; this is insulated with tapes and on the top of the taping a second sheath of lead is drawn. I understand that a distinct insulation is got between the two lead sheathings. This would ensure that no electrolytic trouble takes place on the inner lead. We have tried troughing treated with Stockholm tar, creosoted troughing, and Haskinised wood. Stockholm tar is little or no protection to the wood, but creosoted and Haskinised wood have proved quite satisfactory. We have always made certain that the creosoted wood was perfectly dry before using it. For many years now we have used pitch and pitch oil for filling-in compound. We were satisfied that this was better than bitumen for many reasons. Pitch has been used for the protection of iron and lead pipes in the gas department for forty years. The only point upon which we were not satisfied with pitch was its mechanical strength, and for some years back we have experimented with mixtures of pitch and talc, pitch and whinstone dust, etc., and have now adopted pitch and whinstone dust. I consider pitch is superior to bitumen for running-up cables for the following reasons: If the cable or troughing is at all damp, where hot bitumen is poured it froths up and gives anything but a solid job. The specific heat of bitumen is 0·8 as against 0·5 for pitch, and consequently the use of bitumen heats up the cable very much more than is the case with pitch. We have also recently got cable supports made of pitch and whinstone dust and are trying these in place of porcelain. I congratulate Mr. Vernier on his jointing methods. They undoubtedly have supplied a solution to the question of expansion and subsidence. Of course, a standard cable when heated does to a considerable extent take up the expansion of the cable on the lay of the different strands.

The only new point that comes to my mind that has not been referred to in the paper is one of considerable importance, and that is filling up the spaces between the different wires making up the cable, with some plastic material so as to exclude all air from the inside of the cable and prevent water or moisture from travelling for great lengths along the cable. If this is not done, it has been found that when the cable is run up solid with hot pitch or bitumen, a considerable expansion of air inside the conductor takes place, and if the end of the cable is sealed up while the cable is hot, the air-pressure inside the cable, on cooling, is less than that outside and a pinhole may draw in a considerable amount of moisture along the cable. For the protection of our extra-high-tension mains, on the top of the wooden troughing, such as is illustrated on page 217 of the paper, we have laid

common flat iron 7 in. × ¼ in. thick in 3 and 4 ft. lengths. This will stop a navvy's pick or any other pin being driven into the ground. Mr. Lackie.

Professor F. G. BAILY: Could slag or glass wool not be used in place of cotton, jute, or hemp, for filling and packing at glands or bushes of joint-boxes? It would be chemically inert, and it would soak up the pitch quite as much as is required. It would not rot like vegetable material, and it would be more absorbent and softer for packing than asbestos. I should also like to know whether in the expansion and contraction of cables from heating and cooling there is any sign of the lead not going back when it has gone forward, because I have known in connection with combinations of lead and iron pipes, for example, that after subjection to heating and cooling the lead would thicken up in some places and be thin in others, and possibly the same action may occur in cables. One other point I might mention. Mr. Vernier has laid great stress in the creeping-in of moisture in unlikely places. That reminds me of an old experiment I once made. Thinking to invent a very satisfactory filling material for junction-boxes, I prepared a mixture of resin oil and sand, which I thought would not only have the density of the sand but would have the non-hygroscopic quality of the oil, so that any water that came in through the lid would remain on the surface. On putting water on the surface of the mixture, however, I found that the water gradually, grain by grain, percolated through the sand, displacing the oil, until I had practically wet sand, which, of course, is quite a good conductor. I imagine that the mixture of pitch and whinstone dust that Mr. Lackie uses ought to be kept fairly hard, or he may experience the same result that I did. Professor Baily.

Mr. E. G. TIDD: In a paper of this kind the portions that specially appeal to the individual are references to work with which he has been more or less associated; the small portion of the paper which particularly appealed to me is Mr. Vernier's reference to the bitumen fibre conduits which he states are much used in America. About 30 miles of this duct have within the last year or two been laid by the Glasgow Corporation Tramways Department, and about a similar quantity by the Edinburgh Corporation. I thought it might be of interest, and so have here some further samples, which I have placed on the table. Mr. Vernier showed what is termed the "socket joint duct" only. I have also placed on the table some of the more recently introduced "sleeve joint ducts." The former are generally used for laying in concrete, whereas the latter can be laid direct in the ground. As Mr. Vernier explained, the joints are made watertight in the case of the socket joints by taking a 3-in. wide strip of unbleached calico of sufficient length to enable the ends to overlap, dipping it in hot compound and wrapping round the joint, a further compound being applied to the outside with a brush, if necessary. In the case of the sleeve joint duct, it should be noticed that the joint is made with a slight taper. It is made absolutely watertight by smearing a thin solution of linseed oil and whiting, or other suitable compound, over Mr. Tidd.

Mr. Tidd.

the ends before pushing them into the sleeves. As both the ends of the ducts and the inside of the sleeves are carefully tooled this makes an absolutely watertight joint. Amongst other claims for this duct are the prevention of mechanical injury to cables in drawing-in, due to sharp edges and hard pimples which occur in stoneware duct. In the case of the Key fibre duct, as the joints are accurately turned, practically perfect alignment is insured, added to which the nature of the material is such that it is rubbed smooth by drawing the cable through it, and a good lubricating surface is provided, so that incidentally it is possible to draw a given length and diameter of cable through a considerably smaller duct, and with less strain than is required where stoneware duct is used. Mr. Lackie referred to the fact that this duct could be laid closer together than stonework ducts as a disadvantage on account of the risk of a short-circuit from one duct to another, as he had known to occur in multi-way duct; but I think that if Mr. Lackie considers the matter for a moment, he will see that the two cases are totally different. In a multi-way duct there is a single wall between the two conductors, and it might be very likely for a flaw to occur in that wall, but with two separate ducts, however close together they were, it seems to me to be quite impossible. A further question which crops up in connection with ducts is that of electrolysis, and whatever may or may not take place in connection with stoneware ducts, the bitumenised fibre duct is absolutely immune from any troubles of this kind.

Mr. Vernier goes on to criticise the solid system and the advantages of wood and earthenware troughing, and he makes some criticisms in regard to the latter on account of the pitch or bitumen not adhering to the glazed surface. He also criticises wood troughing so far as its preservative treatment is concerned. Cast-iron troughing also comes in for some criticism. I have placed a fourth kind of troughing on the table, viz., the Key fibre troughing, which, as will be seen, practically consists of the duct which I have been referring to, made into a trough by taking out a section to form the lid. This seems to meet practically all Mr. Vernier's various objections. There is no risk of creosote doing any damage; there is no glazed inside to prevent the filling adhering to the surface, rather the contrary, seeing that the filling and the material have very much the same constituents, which enables the two to combine in an absolutely perfect manner.

The Chairman.

The CHAIRMAN (Mr. SAM MAVOR): Mr. Vernier's paper and the discussion which has followed are an indirect testimony to the excellence which has been attained in the art of cable manufacture. The difficulties of the mains engineer appears to be associated with the proper laying of the cables, and especially with the proper jointing of them; the cables themselves appear to be almost perfect. I had occasion some months ago to go underground at the Hulton Colliery, where the great disaster occurred in December. I went down below with a number of officials a few days after the explosion, and found the cables in the mine buried under many thousands of tons of rock which

had fallen from the roofs of the roadways. The cable was 500-volt three-core armoured cable, and it is a very interesting fact that although nearly the whole cabling system in the district of the mine most affected was buried under immense falls of rock, we tested the system from end to end and found the insulation practically perfect. The lowest insulation was 50,000 ohms, and this was with all the boxes connected. That is a tremendously strong testimonial to the mechanical qualities of lead-covered and armoured cable. The Chairman.

Mr. C. VERNIER (*in reply*): Mr. Snell asked whether there was not a possibility of leaving air spaces by using the vacuum method of filling joints. With a 29·5 in. vacuum I do not think there can be much air left, especially when the vacuum has been maintained for 40 minutes, and considering that it takes only 30 seconds to attain this vacuum. With the constant warming which takes place there should be no possibility of air being present at all. Mr. Snell also referred to temperature limits and current densities at 20,000 volts. I am afraid I have no figures on that point. All I can say is that it is possible to run paper-insulated cables to a temperature of 150° F. continuously, but the current densities corresponding to this temperature have never been fully determined for various thicknesses of insulation and for the various types of cables and under different conditions of laying. There is no doubt that a great deal of experimental work and research will have to be done on this question, and similar questions, on the behaviour of cables. Such research is very much needed. We power engineers are, I am afraid, rather too busy to investigate questions of that sort; but if the Institution should at some time go in for research in the way that other institutions do, we could supply them with any number of problems for investigation. Then, Mr. Snell referred to current densities of 1,800 amperes per square inch. That is a question which depends entirely on the size of the conductor, and he did not state what section of conductor he had in mind; but this current density is well within the limit for a 0·05 sq. in. 20,000-volt 3-core cable. Mr. Welbourn referred to lead-covered cables as the only means for doing high-tension work. I do not think there is any question that at the present time the lead-covered cable is the only feasible cable to use. With regard to the life of cables, he asked what evidence I had for stating that 20 or 30 years was their probable life. I have no evidence except what he mentioned himself, that some cables have been at work for 20 and 22 years. But there again it is all a question of research. I do not think 20 years can be quoted as the life of a cable, because it is a question of the voltage a particular cable may be working at. Mr. Ferranti has told me this evening of some cables, between Deptford and London, which are still running, which were put in 22 years ago. Those are 10,000-volt cables. The cables referred to by Mr. Welbourn were probably low-tension, and that makes all the difference. What the life of a 20,000-volt cable will be I do not think any one can predict with certainty at the moment. Various changes may take place in the cable over long periods of time. Mr. Vernier.

Mr Vernier. and I do not think any one would commit themselves to saying what the life will be. There is, for instance, the dielectric hysteresis; there are possible changes in the insulating properties of insulating oils under continued high temperatures, from running at high-current densities, and other problems which affect the question and require investigation. I very strongly endorse Mr. Welbourn's remark that the continuity of the armour as well as of the lead must be maintained. That, I am afraid, is a point that is not often as much appreciated as it should be. It is a very common experience to find people who take care to maintain the continuity of the lead, but who leave the armour to take care of itself. They just bind it off at the end on to the jute, and do not make it continuous. It is possible to get quite respectable voltages induced in that armour if it is not bonded to the lead frequently, at the joints particularly. I also agree that after earthing a cable, one should not sit down and wait and see what happens. Conditions do alter, and, as mentioned in the paper, far more can be done by checking the conditions of running and providing against those conditions. For instance, if a certain system of earthing is carried out, as Mr. Trotter has mentioned, the earthing should be done at the most negative points. That is what we are doing ourselves, but the method I mentioned in the paper has been used very extensively I understand. It saves testing—that is one of the chief reasons for using it, but one should not sit down and think that everything is going on merrily. On a big system, especially on a power system which covers large areas, all sorts of people commence starting up a small tramway here and a small tramway there, or a railway company makes an extension, so that the distribution of the earth currents is altered considerably. It is necessary to test periodically, and to keep in touch with these people, so that they will run their system as it ought to be run—that is, put their negative feeders at the proper place and maintain their distribution as it should be. With regard to the branded joints, the tests mentioned were made on a 0·1 section. Mr. Highfield made a rather interesting suggestion, that we should use direct current for pressure testing the cables. It would be extremely convenient in one way—I mean the testing of very long lines of great capacity requires transformers of a considerable size. The A.E.G., in testing these 20,000-volt cables insert a choking coil, in parallel with the cores of the cable, for the purpose of cutting down the capacity current. The only difficulty to my mind is how to get 300,000 volts direct current readily. It is not a very easy thing to obtain.

Mr. Patchell rather took me to task about the Board of Trade earth shield. I have not the rules with me, but to the best of my recollection the Board of Trade regulations state that one shall take steps to prevent the ground becoming charged in the event of a fault. That may be done either by the use of a copper shield, or alternatively, by armouring. I do not think that the Board of Trade really insist that there shall be a copper shield or an armouring. If it is possible to find some other method of preventing the ground from becoming charged,

I think the regulation covers that. Mr. Mitchell also asked whether it was possible to draw water by the vacuum method. The reply I made to Mr. Snell's remark applies here also. I was much interested in Mr. Roger Smith's remarks about the Howard troughing, because I had heard of the use of it on the Great Western Railway, but I had not any very definite particulars. I am not at all sure, but I have some idea that a pressure test was specified on that particular cable, and if Mr. Smith will kindly mention whether that is so, and if so the results that he obtained between the lead sheath and earth in that troughing, it would be very interesting to other possible users. If I understand rightly, the whole of the troughing is laid on a concrete bed. [Mr. ROGER SMITH: That is so.] That would, of course, tend to keep the faults down considerably. The troubles on railways are very severe owing to the vibrations. I may say that on a similar railway system the faults from vibration represented about 20 per cent. of the whole, and it is becoming quite a serious question—that is, with a solid system and not with armoured cables. I do not know of any case where it has occurred with armoured cables. The construction of a concrete bed is a very serious capital item, and I am afraid it is not everybody who can afford to lay it down. Mr. Howell asked: Why use concrete with ducts? I hardly think that any one would care to use ducts without concrete unless they had sufficient mechanical strength to resist external damage without it. Then again, I doubt whether thickening up the wall would be sufficient, at any rate unless the system is fitted with some of the very latest types of instantaneous protective gear, because with ordinary relay systems, two or three yards of cables, conduits, and everything else, can very often be burnt out in clearing a fault. The cost of draining is certainly a big item, but in some cases it has been found well worth doing. It depends very much on the situation of the ducts. Ducts may get filled up with 3 or 4 ft. of water in every manhole—it depends very much on the situation of the ducts—and if there is a breakdown those ducts can sometimes be bailed out for several days before it is possible to get into them.

Mr. Howell mentioned that a tile of the watershed type was an advantage with crowbars. It seems to me that that depends on what angle the crowbar gets to the tile. If it happens to get square on to the watershed surface it is a distinct disadvantage. With regard to making a longitudinal channel to allow the pitch to run, I do not know whether that is quite an advantage. The method I prefer is to fill the troughs up in two or three pourings, with intervals for cooling and shrinking, and then to pour surplus pitch on the surface of the troughing; then lay the tiles a few inches in front of the space where they are going to rest finally, and drag back the pitch with it which gets between the tiles and seals the joints. I take it that what is intended in this case is that the tiles should be put down first, and then pitch poured in at an open place, which would flow along under them. I do not myself approve of this method, as it is much more likely to leave cavities. Then Mr. Howell

Mr. Verma

Mr. Vernier. rather suggested he would not lay armoured cables in water-logged districts. We are doing it, and a little later on perhaps we may be able to give him the results. At any rate, we have no hesitation in doing it, not with that special waterproof covering. I may say we do not claim that these coverings are anything like as good as we should like them to be. We certainly are putting pressure on the cable-makers almost every few months to give us something better. With regard to the fact that there are some better coverings, I happen to know of them privately, but I could not describe them at the moment. Mr. Howell's remarks as to hob-nailed boots rather strengthens my dislike of the solid system. It is due to the fact that it is necessary to use unskilled, or practically unskilled labour, and carry out the work under all conditions of weather. There is nothing more disappointing than when a length of cable has just been drawn into the trench, to get a heavy storm come along and simply drown one out. The sides of the trench fall in, and all sorts of things happen which make good work almost impossible. Mr. Howell also spoke about laying it in 10 or 12 ft. at a time. If one could afford to do it in that way I have no doubt a very good job could be made of it; but the paper deals with work on a very large scale, and it is nothing unusual to open a quarter of a mile and do that length at once. With armoured cable, it can be dropped into the trench with the certainty that it is going to be a good job. I am glad to hear that Mr. Trotter agrees with the system of armoured cables and creosoted planking, and also that he supports my view of the 2-in. plank.

Mr. Stedman made some mention of the problems involved in running cables across rivers and docks. This is rather special, and I did not intend to deal with special work in this paper. In the small amount of work I have done in this connection, apart from low-tension work, I have used the ordinary type of lead sheathed and armoured cable for this. I do not think that there is any special difficulty to contend with, the chief trouble being the picking up of cables by anchors. With regard to the potential difference sometimes found between rails and lead-covered cables, I think this is due to the rails not being earthed. Railway lines may be fairly well insulated by the sleepers for long distances, and yet be in contact with earth at some distant point, and a test between cables and rails frequently only results in obtaining the difference of potential between two earth-points some distance apart. I remember a case where there was a voltage between a cable sheath and some colliery rails amounting to 1½ volts. Some of my Post Office friends tell me there is a difference of potential amounting to a good many volts between distant towns in this district, which gives them trouble in connection with their telegraph circuits. It is, again, very probable that in some cases the cable and rails form a couple owing to their being laid in ashes in which there is some active chemical. In those cases where the polarity reverses, this is undoubtedly due to leakage currents emanat-

ing from some source of electric supply, and it is at times quite extraordinary how such leakage currents are met with miles away from any known source of electric supply. To distinguish between Trinidad bitumen and pitch is quite easy to any one who is familiar with both, as the pitch presents a different surface and is more easily broken. The usual proportion of oil which we use in pitch is one part of oil to seven of pitch in liquid form. This is best determined by experiment with the particular quality of pitch used, as this may vary. Mr. Vernier.

Mr. Vesey Brown made some remarks with regard to switching on 19 miles of 20,000-volt cable. Although the matter of switching is not in my hands, one end of the cable being in another company's area of supply, I do not know of any special devices being used on that cable. This length was switched in regularly direct on the system for over a year in this way. I say for a year, because it has recently been shortened by a new sub-station introduced to supply a consumer, which reduces its length to 16¼ miles. Since then electrolytic arresters have been installed, as the contractors, who have to maintain it, have suspicions of surges; but so far as my knowledge goes these have never operated. This particular cable, I may say, forms part of a continuous length of 20,000-volt cable 37 miles long, connecting up two large power stations running in parallel. This point about doing without charging devices seems to be one on which there appears to remain a good deal of unnecessary doubt. Several speakers referred to it in the discussion on Mr. Patchell's paper in 1905, and several had evidently installed such apparatus and subsequently found it unnecessary, in one case quite accidentally. The power companies in this district have never attempted to put in charging devices, and have always switched on without them. [Mr. VESEY BROWN: Is this always done on closed circuits?—Mr. P. V. HUNTER: It is always done on open circuits, and I have never known of surges occurring due to switching-in.] Theoretically, and with a sine wave, the pressure rise on switching-in should not exceed double the normal; but Dr. Steinmetz and others point out that in the complex conditions of a large power network this figure may be greatly exceeded (possibly up to four times). Even so, paper-insulated cables will stand this and considerably more quite easily for the extremely short time during which the surge lasts—provided, of course, that there is no resonance between the surge frequency and the system frequency or its harmonics.

In reply to Mr. Hunt, I have not observed the effect of switching-in with an oscillograph, but Mr. Patchell's paper* gives a number of oscillograph curves for the switching-on of various combinations of feeders and in only one or two cases is there any approach to a rise of pressure of twice the normal, while it should be noted that the switching in these experiments was done between brass contracts in air, which are much more liable to produce a rise of pressure than modern oil-switches. Further evidence is given in Mr. Patchell's contribution

* *Proceedings of the Institution of Electrical Engineers*, [illegible]

Vernier. to the discussion* on the same paper, where the rise observed in switching-on open-circuited rubber cables did not exceed 2·25 times normal pressure even with a very bad wave-form. It is of special interest to notice that in switching-on the same cables with a transformer on open circuit, connected to them at the far end, the pressure rise was increased to 2·7 times the normal pressure, so that this method appears to defeat its own object.

With reference to Mr. Vesey Brown's suggestion that it might be better to use cable-charging gear and reduce the cost of insulation instead of providing cables with such great factors of safety, I should mention that it is only usual to provide insulation on E.H.T. cables which will stand the normal working pressure continuously with a factor of safety of about 3 or 4; but the physical properties of paper-insulated cables are such that the factor of safety for a cable so designed is of the order of ten to twenty for such transient phenomena as switching-on surges. It takes time to break down insulation, and a very good illustration of this is given by Dr. Steinmetz, which may be of interest. He points out that the sparking distance in air for a certain voltage varies very considerably with the time of application and gives the following figures:—

Voltage	35,000 volts.
If continuously applied the maximum sparking distance equals	2·00 in.
If applied for 0·005 second the maximum sparking distance equals	1·33 „
If applied for 0·002 second the maximum sparking distance equals	0·75 „
If applied for 0·0005 second the maximum sparking distance equals	0·25 „

With air, ionisation no doubt takes place with the longer times of application of pressure, but similar results are obtained with solid insulations. Such figures as those given above will probably account for the somewhat erratic operation of horn-gap arresters so frequently met with, the proper setting of which is usually a most difficult matter in order to ensure that they will only operate when required to do so and will then do so with certainty. As an example of what 20,000-volt cables will stand, the following are some of the tests which such cables have passed satisfactorily:—

100,000 volts for 5 minutes at ordinary temperature.
50,000 volts for 24 hours at ordinary temperature.
90,000 volts for 2 minutes at 156° F.
30,000 volts for 5 hours at 156° F.

As to the explanation why E.H.T. cables break down, I am inclined

* *Proceedings of the Institution of Electrical Engineers*, vol. 36, p. 139, 1906.

to agree with Mr. Hunter that this is a question of heating by dielectric hysteresis. Mr. Vernier.

Dr. Thornton's contribution on this point is exceedingly interesting, especially that part of it relating to the creep of hysteresis, which is new to me. Hochstädter * has published the result of some investigations on the dielectric properties of modern high-tension cables, in which the dielectric loss is shown to diminish rapidly between temperatures of 10° C. and 40° C., after which it increases fairly rapidly. This seems to me a somewhat unexpected result, and one which I think requires further elucidation. Whatever the actual cause of breakdown may be, there is no doubt that cables break down more readily under high temperatures. This point is not often realised, and cable tests should always be specified to be taken at the highest temperature at which the cables will have to run, as this condition is much the most severe which they will have to meet in practice. I have dealt with this matter somewhat at length, as it is certainly a matter of very great surprise to me to learn from Mr. Clothier's remark that switchgear manufacturers are still called upon to provide cable-charging devices at the present time. This, in my opinion, is a needless waste of money, and it is scarcely necessary to mention that the satisfactory operation of a large power system like that of the North East Coast Power Companies' would be seriously interfered with if such devices had to be used, to say nothing of the extra complication of switchgear. I may add that I have never met with a case of a breakdown of a cable due to switching-on at full voltage, although throughout the above companies' 6,000-volt system, all roller spark-gaps and other like protective devices have been dispensed with for several years past. They are only, at present, retained on the 20,000-volt cables to meet the requirements of the contractors who are responsible for the maintenance of the cables. Then again, it is a matter of daily routine to switch on 6,000-and 11,000-volt overhead lines containing long lengths of underground cable in series direct on to the system without any charging gear or protective devices of any kind; and there has never been a breakdown, although the cables are of the standard design for the particular voltage. I suppose those engineers who still use charging gear would consider this procedure absolutely reckless. I certainly agree with Mr. Vesey Brown that the extra money laid out on a good network is money well spent, for if it is not spent in the first instance it will surely have to be spent several times over afterwards. The fact that the cost of cable work has a tendency to increase has been mentioned. While this is true, it is equally true that the maintenance charges on networks laid down during the past ten years have been greatly reduced. This question of capital cost is certainly not one which can be considered apart from the maintenance charges and the ultimate life of the cables.

I was very much interested in Mr. Robb's description of their Forth Bridge difficulties. I have had similar troubles with cables in steel roughing on walls such as can be seen on the railways in this district.

* *Elektrotechnische Zeitschrift*, vol. 31, p. 467, 1910.

Mr. Vernier. There is one length about 300 yards long which has given considerable trouble at cable joints, but since using expansion joints no further trouble has been experienced. I am glad to hear that Mr. Robb has found bonding the salvation of his system. There is no doubt that bonding is one of the most important requirements of a cable system, and people who neglect it or carry it out without proper care only have themselves to blame for any trouble they have. I also notice that Mr. Robb mentions that petroleum jelly is likely to be of assistance in preventing electrolysis, but I do not see how that can very well be, as the iron pipe and cable when well bonded together can be looked upon as one metallic mass, and, of course, corrosion will start outside although it may eventually reach to the cable.

In reply to Mr. Sloan on the fixing of expansion joints, it is usual to provide that the joints allow for a certain movement which it is considered is not likely to be exceeded. Each joint takes up a certain amount, so that the 4 ft. 6 in. movement, or whatever it may be, is spread over a number of joints. If the joints, however, were being put in for overrunning alone and there was no suspicion of subsidence or earth movements, it would be an advantage to take account of the temperature in setting the joints. This can readily be done, as with a particular expansion fitting the total movement for which it is designed can be split into any proportion of expansion and contraction allowance. Thus, with a 6-in. movement fitting this can be divided into 3 in. expansion and 3 in. contraction, or 5 in. expansion and 1 in. contraction, and so on. I should, however, mention that although the expansion of the conductor may be 4 ft. 6 in. in a mile, the movement at the joints is usually much less than this, as, owing to the great friction of the cores inside the cable, a certain amount of this expansion is taken up laterally by slight buckling. This explains why such troubles are not met with to any serious extent until we begin to run cables to high-current densities.

I agree with Mr. Turnbull that wood-troughing is not a good article, and I think that it has seen its best days. At least, I do not think that we shall use it in this district again. The makers of the wood troughing adopt the plan shown in Fig. 3, because it is a simple matter to retain the proper width of the trough by cutting a strip of wood to the exact inside width, and nailing the outside strips to this. In the construction shown in Fig. 4 it is not quite so simple to keep to the exact width, as a piece of wood to form a gauge has to be inserted while the side strips are being nailed on. With regard to pitch running down a hill, I do not know of any case, and I think that pitch should not be used in such a soft condition that it is likely to do this. I am glad to hear that Mr. Turnbull favours armoured cable, and that he has had such satisfactory results. We have some cables in Newcastle which have been laid eleven to twelve years, and are still quite satisfactory. These are laid in sandy soil. With regard to the filling of the strands, there is only one material to fill with in the case of electrical high-tension cables, and that is with the same oil as is used for impregnating the paper, the

whole of the cable being impregnated at one time under vacuum. But perhaps Mr. Turnbull intended to refer to low-tension vulcanised bitumen cables with bitumen-filled strands. This is an excellent thing. One of the greatest troubles with vulcanised bitumen cables is caused by water getting in at a fault, which might run up the strand for several hundred yards. I once had an experience of this sort (in fact, I have had several) on a low-tension vulcanised bitumen cable, through water getting in at a negative fault and running down a hill 200 to 300 yards. I had the cable cut at the bottom of the hill and slipped on a rubber tube about 1 in. in diameter, sealed up at the end, and left it alive about a month; at the end of this time there was about a foot of water in the tube. I then re-insulated all the service joints on the run. This cable has now been running for about eight years, and since that time has given no trouble. Mr. Vernon.

Mr. Hunt asked about proprietary soldering fluxes. I have had several analysed, and I do not know of any of these soldering fluxes entirely free from acid. I always use resin for soldering cores, but for soldering the braid joints I use a mixture of resin and tallow in equal quantities, and I find this is better than resin alone, because pure resin is apt to clog and dirty the fine braid. With regard to Mr. Hunt's remarks as to whether the breakdowns from surges might not be due to cumulative damage, very careful tests have been carried out by Hochstädter,* with an oscillograph, to determine whether cables had anything in the nature of an elastic limit, and he found that no change took place in the properties of the cables right up to the moment of breakdown.

A number of speakers have mentioned the question of surges, and I am in agreement with Mr. Porter's explanation. It is not always realised what a tremendous amount of energy may be set free in the event of a short circuit on a large power system, particularly if in the neighbourhood of a big power station. While the short circuit lasts, there may be a discharge of several hundred thousand kilowatts, although the plant capacity may not exceed 50,000 k.w., and I have known the case of a large system where a severe short circuit on a cable has lowered the voltage from 6,000 to 5,000 volts momentarily throughout the system. In this connection the value of an instantaneous system of balanced protective gear such as the Merz-Price cannot be overestimated, as this will usually open the switches before the short circuit breaks itself; and as these switches are now invariably of the oil type, the current is broken at or near zero-point, thus preventing excessive rises of pressure, shock to the system, and interference with the supply.

Mr. Morton has also referred to this system of protection in another connection. This acts so quickly that it is sometimes a great nuisance to the mains people, but it is just that feature of its operation which has proved of such importance to the consumer. It is in many cases necessary to put a pressure test on the cable to break down the fault

* *Elektrotechnische Zeitschrift*, vol. 31, p. 467, 1910.

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Mr. Vernier. sufficiently for localising tests to be put on. On the other hand, it is of very great advantage on a large system, as the faulty feeder is immediately isolated, and it is not therefore necessary to sectionalise a number of interconnected cables in order to find the faulty one, as so frequently happens with other systems of protective gear.

In reply to Mr. Hunt, I have already remarked that paper cables have a very large factor of safety for a rise of pressure lasting but a short period, and I think it is quite within reason for a 20,000-volt cable to withstand momentarily from 200,000 to 300,000 volts, or even more. I know of cases where 6,000-volt cables have stood up satisfactorily to surge pressures of 100,000 or 150,000, as evidenced by sparking which took place across large distances on switchgear to which they were connected. Several speakers have given their views upon the methods they would adopt to guard against electrolysis, and all, with one exception, are in favour of earthing the lead. Mr. Dawson is the exception, and although the method he deals with in his contribution is outside the scope of the paper, as the Board of Trade regulations do not admit of its use on high-pressure cables, I feel that I must utter a note of warning to those who might be disposed to consider the adoption of such a method. The danger in breaking-up the lead sheath into sections at joints, leaving aside the question of its efficacy as a prevention of stray current electrolysis, is that on low-tension networks consisting of single core or multicore cables, which must of necessity be heavily fused, faults occurring on one pole may render the lead alive without blowing the fuses and cause what I term "live-lead" electrolysis as distinct from "stray-current" electrolysis. This may speedily destroy a considerable amount of cable and also pipes in the vicinity, according to the polarity of the lead sheath to earth. Mr. Dawson may attribute his immunity from this sort of trouble to the fact that his cables are of the concentric type, which, when they break down, generally develop into a "dead short circuit" immediately. I have come across several serious cases of this "live-lead" electrolysis, which, since the voltage to earth may be considerable as compared with that of stray currents, causes very rapid corrosion—in fact, a considerable amount of cable can be ruined in this way in the course of two or three days. There is also great danger of electrolysis taking place from small leakages over cable ends at joint-boxes and on switchgear.

Mr. Dawson further discusses the question of current leaking from cable sheaths on to water pipes, assuming the neutral wire of the supply is connected to these pipes. I think it is extremely unwise to connect the neutral wire to water pipes at the generating station, as this will certainly cause electrolysis on the pipes and create the sort of leakage paths which he has discussed at length. In earthing the lead sheaths of a lead-covered network at the power station, care should always be taken not to earth to the same earth-plate as is used for earthing the neutral wire, and an entirely separate earth-plate should always be put down for this purpose at some distance from it. Lead bonds I would most strongly object to. All bonds should, in my opinion, be of

copper, of equivalent conductivity to the lead sheath, and never less than 0·05 sq. in. in sectional area, as otherwise we can never be sure that they have not gone up into smoke in the manner described. Mr Verma

I agree with Messrs. Beaver and Hunter that with most woods, when used for bridges and bushes, the corrosion of the lead sheath is chiefly due to the acid electrolyte facilitating electrolysis. This is not so with all woods, however, as oak and possibly other woods have a considerable purely chemical action on lead and will corrode this through very rapidly in the presence of air and moisture, the action in the case of oak being similar to the Dutch process of manufacturing white lead.

Messrs. Burrows and Hogg's experience with expansion joints bears out very well the similar successful results I have obtained with such joints. Expansion joints for cables are, of course, no new thing, and I believe were first used by Mr. Ferranti on the Deptford mains laid twenty-two years ago, which were constructed of solid copper tubes. The chief object in the design of the joint described in the paper was to obtain a joint which could be used without any radical alteration of the usual designs of joints and joint-boxes in ordinary use, up to and including the highest voltages, and which could be so cheaply made as to encourage its universal adoption. The question has been asked as to the need of expansion fittings at every joint. It is certainly most important that all joints in the affected area should be of the expansion type, as otherwise intermediate non-expansion joints will continue to give trouble. It is in many cases most difficult to define where an affected area begins and where it ends, or to decide upon what is likely to prove an affected area at the time of laying the cable. For this reason, as well as for overrunning possibilities, the extra cost of putting in expansion joints throughout being so slight, it is well worth doing this in the first instance. I know one length of about 1 mile of cable where as much has been spent on subsidence breakdowns in less than three years previous to the use of expansion joints as would have paid for inserting expansion joints in the first instance on over 50 miles of the same cable system. Several speakers asked for further information on the use of such joints. In reply to Mr. Beaver, very few breakdowns have taken place in the cables themselves as compared with breakdowns at joints. When such breakdowns have taken place, it was usually after the nearest joint had buckled considerably, and thus more resistance to movement came upon the cable, generally at a bend. My experience has been that movement of the conductors is always transmitted to the nearest joints, which, as they are weaker than the cable, either buckle or break. Expansion due to heating is, of course, very much more easily transmitted, as the expansion takes place uniformly along the cable and the movement becomes cumulative up to the joints at each side. In connection with subsidences, it is necessary to consider plain lead-covered cables laid on the solid system and armoured cables laid direct in the ground separately. With solid systems both

Mr. Vernier. tension and compression troubles may be experienced. Compression is usually caused by a moving stratum of earth which grips the sockets of the troughing and drags the lead sheath, paper insulation, and conductors along with it up to some point where movement ceases. With armoured cables laid direct in the ground, I have never experienced a case of compression trouble. This appears to be due to the fact that moving soil cannot grip this type of cable so tightly, also to the fact that any compression on the spiral armouring tends to make it buckle and open out and so lose its grip on the lead sheath. Wire-armoured cables, in reply to Mr. Morton, are of great assistance in diminishing troubles from subsidence, but they do not avoid tension troubles, as the spiral armouring can stretch considerably, on a long length, like a rope, although not to the same extent as plain-covered cable. Slack cable at joint-boxes or elsewhere is quite ineffective, unless the subsidence is so close to it that the slack can draw out. The lead sheath of cables without slack rarely shows any appreciable movement at cable glands, and out of some fifty cases, all on solid systems, I have only found one case where the lead was damaged due to external damage by the tiles, but all the other cases only showed slight corrugations in cases of compression. Some compression movement on the solid system is, of course, taken up at each trough joint, as the ends of the troughs are seldom butted up close to one another.

In reply to Mr. Vesey Brown, the thickness of the tubes used for the expansion fittings varies from 1/16 in. to 3/32 in., while the flexible braids are designed from the point of view of current-carrying capacity. The tube does nothing more than maintain the ends of the conductors in alignment and, as it is quite a loose fit on them, it does not need to have any great strength. In reply to Mr. Addison, the movement of the conductors against one another is not more likely to reduce the dielectric strength than the constant movement which takes place with all cables due to heating and cooling under changes of load. Further, the bending the cable receives in the process of laying is usually much more severe, and it is known quite well what cables will stand after the usual severe bending tests.

Mr. Bridges has dealt fully with the drawn-in system, and I agree with him that this system requires a good deal more consideration than it usually receives. Coffin-shaped manholes are best for multiple-way ducts, as in this case the pipes cannot be splayed out. I think a better design of manhole than that shown in Fig. 2, although a little more expensive, is, instead of splaying out the pipes, to bring them one to each side of a brick wall dividing the manhole longitudinally in the middle. This gives practically two separate manholes, and any damage from the cables on one side of the wall cannot be transmitted to those on the other; also a perfectly straight lead into the pipes can be obtained for drawing in without using covers with very large openings.

The use of taped and braided cable for drawn-in work has been criticised by Mr. Morton and other speakers. The type of braiding I had in mind is similar to the protective covering described in the

paper in connection with armoured cables, or with the more recent improvements of these coverings. I agree that in severe cases of electrolysis it may not afford any great protection, and in such cases the conditions should be remedied, but I have in mind cases of extremely slow corrosion due to electrolysis in pipes which are practically dry. I have seen such slow electrolysis on cables in use eight years and which are still running. I think in cases of this kind a taped and braided covering would prolong the life of the cables, while against chemical action it would, I think, be an even greater protection. With regard to the use of braided cable for laying solid, there is no doubt that filling compositions adhere very closely to such braidings, even if damp. Those used to laying vulcanised bitumen cables solid can bear this out, and it is due to the impregnating compounds in the braidings, which exude when the hot filling composition is poured on. I have no doubt that a very great improvement could be obtained with plain lead-covered cables on the solid system if the cables were tarred or coated with a similar composition by the makers before laying. Mr Verner

The joint Mr. Mitchell has produced is practically on the lines shown in Fig. 15 of the paper and should be an improvement on tape-insulated joints. I prefer, however, to allow the compound to flow between the separate cores as far as possible, so as to increase the leakage surface. The chief reason why conduits are laid in concrete is for the mechanical protection this affords against external damage. It also renders the system, if properly laid, much less accessible to external moisture, due to water getting in at the joints of the pipes or conduits. The use of concrete further makes a very rigid system not so likely to be affected by subsidence. The accessibility of the draw-in system, claimed as an advantage, is often but an excuse for people who are poor hands at fault locating, as by opening a few joints the fault does not require locating closer than a few hundred yards. With proper tests a fault on a buried system, even of several miles, can be repaired as easily, while the cost of repair is usually a mere fraction of what it would be on a draw-in system. Buried systems do not require periodical inspection, and this saving on a large system is quite an important matter. As to protecting cables on the solid system against external moisture, the question is an important one, and while I think the system is not sufficiently practical for work on a large scale, had I been discussing distribution work in towns my views would have been somewhat modified. It depends greatly on the facilities available for carrying out the work properly and the conditions which have to be met, but I think that in any case with this system too much is left in the hands of men who in the ordinary way are recruited from the ranks of unskilled labour.

Mr. Macleod has referred briefly to the expansion of cables. In regard to the expansion of cables when running at high-current densities, although the conductors do expand 4 ft. 6 in. per mile, the cable itself does not expand so much. There is a limit where lateral displacement cannot take place any further and where it comes on the

Mr. Vernier.

joint. If it was not for that, trouble from heating of cables would be much more frequent. It is only when high-current densities are reached that there is need to fear. With regard to the use of expansion bends, I do not think, unless the subsidence takes place quite close to where the bend is located, that it can be provided against in that way, because the cable cannot be got to pull through the ground, but it stretches at the point where the subsidence takes place, and the conductors draw right through the lead sheath to the nearest joint and pull it out. That has been my experience. If it is wished to provide against a subsidence and it is known where that is, a bend may be put at each side and the trouble got over in that way; but the fact should not be lost sight of that it is not possible to bend or straighten out a cable without giving unequal displacement to the several cores. The longitudinal movement at joints is much smaller than the sag of the cable at the subsidence, and it is well known from overhead line work, for instance, that the increased length of wire in a span of 100 yards for an increase of sag from 1 ft. to 5 ft. is only 2 in. This indicates very roughly one reason why comparatively large subsidence movements can be dealt with by smaller limits of movement at joints.

Mr. Lackie referred to the importance of the mains in an electrical undertaking, and although mains' engineers are, I agree, relatively fewer in number, the men engaged in this work might, I think, give us a little more of the results of their experience, because mains represent such a large proportion of the capital of our undertaking, and, what is more important still, they are out of sight. More frequent ventilation of ideas on the subject would in many cases save a lot of money. What is required is dissemination of knowledge. Cable-makers, as might be expected, kept these matters to themselves in the old days, and we had to go to them or suffer from lack of experience. Faults in manufacture are rare, and although it is true, as Mr. Lackie says, that it is not always easy to tell the exact cause of a fault, cable faults themselves are exceedingly rare.

Mr. Tidd practically replied to the next point. I refer to the fact that in a multiple-way duct there is only one wall of earthenware. With a flush joint an inch of concrete, say, can be got in as a minimum, and that will prevent a considerable amount of interference between ducts. With an ordinary socket pipe it is obligatory to put in a greater thickness. With regard to Haskinised wood, I have never had any experience of it. I should like to obtain some particulars of the experience obtained. With reference to whinstone dust, Professor Baily mentioned one point I intended to raise, viz., the absorption of moisture. I have, however, no experience in regard to that matter. It is possibly quite all right, but it wants consideration. The experiment recorded by him is of particular interest, as it may be recollected that a few years ago a good deal of correspondence took place in the electrical press on a method of laying cable in sand mixed with liquid tar instead of the usual pitch or bitumen. Mr. Lackie also mentioned that the heat of pitch is much lower than that of bitumen. I referred to that in

my paper as a point in favour of bitumen, as it does not get chilled against a lead surface and therefore adheres better. With regard to methods of protection, one of the London Companies uses iron plates laid on wood planks, and although it would be possible to go through the iron plate alone it is almost impossible to go through it if it is placed on a resilient surface like a piece of wood. If iron bridges are used, I think the lead should be earthed at intervals, otherwise a number of points in imperfect contact with the lead sheath are obtained, and since these may be of varying resistance to earth, they would lead to trouble. In connection with filling up strands, that is more important in low-tension work. Of course, all high-tension cables have the strands filled up in the impregnation of the cable, which is done under a vacuum, but with vulcanised bitumen cable, if the strands are not filled up, water may run up a considerable distance. Mr. Vernier.

Mr. Tidd has given us some samples of fibre ducts. I am quite favourably disposed towards these. The amount of it used in this country, while on the increase, is nothing compared to the amount which has been used in America. With regard to a solid system with these ducts, I should think one difficulty would be to get the top part quite full owing to its circular form.

In reply to Professor Baily, I have no experience of concrete troughs and I do not know if they are still on the market. I have had no experience of glass wool, but ordinary asbestos is a very bad thing to use on cables: it absorbs moisture so readily. I do not know of any trouble due to the lead not going back, as Professor Baily mentioned. I know that this trouble has occurred in other directions, but I have never met it in connection with cables.

Mr. Mavor also spoke of the perfection to which cable manufacture has been brought. I think we can have every confidence in the products of our leading cable-makers. Personally I have never had any difficulty, and while it may seem a rash practice I may say that we have not found it necessary for many years even to put an insulation test on cables until they are laid and completed ready for pressure testing.

The PRESIDENT: I now ask you to give a hearty vote of thanks to the author for his paper. The President.

The resolution was carried by acclamation.

THE LAYING AND MAINTENANCE OF TRANSMISSION CABLES.*

BY C. VERNIER.

Summary.—The author first describes the three systems that are at present used for laying cables in this country, giving both their advantages and disadvantages. He next deals with the question of jointing, and shows how important this is. The various causes of breakdown on cables are given in conclusion and the ways of avoiding them are stated.

At this date it is scarcely necessary to consider any system other than three-phase alternating transmission, so that the cables employed will invariably be three-core paper-insulated and lead-sheathed, usually operated at pressures between 6,000 and 20,000 volts. Such cables will either be laid in pipes or ducts, on the solid system, or armoured and laid direct in the ground with protective coverings of planks or tiles.

The draw-in system is useful where extensions are likely to be required, but it is too expensive for any extended use. Bitumen fibre conduits seem to give good results. They are lighter and easier to handle than earthenware and take up less space. Single pipes provide greater safety than multiple way ducts, and they can be more easily deviated round obstructions. Attention should be paid to the design of manholes, and the arrangement of the cables should be as neat as possible and such that a breakdown on one does not affect the others. The draw-in system does not provide such good protection against electrolysis as does the solid system. In preventing water draining in, iron pipes are better than conduits and can be made electrically continuous. The cables should be bonded to them at every manhole. When extra-high-tension cables are drawn into pipes wire armouring should be used, and this may take the place of the B.O.T. earth sheath. All cable armourings and lead sheaths should be carefully bonded together and also earthed to an earth-plate at each manhole. There seems to be no difference between this system and the solid system as regards the ease of effecting repairs.

On the solid system wood, earthenware or cast iron troughing is used, and there is little difference in the cost of the first two. The second has rather a longer life than the first when the ground is damp. When creosoting is ordered the only satisfactory treatment is to impregnate the troughing under pressure. There is some objection to creosoting on account of its dissolving action on the bitumen. Creosote obtained as a by-product of coal tar distillation has no action on lead and iron, but wood creosote should be avoided. Earthenware troughing should be well glazed outside, but left unglazed inside. Cast-iron troughing is expensive, but makes a thoroughly sound system, provided the bonding of the separate lengths of troughing is carried out in a substantial manner. The lead sheath and armouring should be well bonded to the troughs at intervals. Asphalt troughing is also used and possesses the advantage that cables laid in it are free from bridge troubles. The weakest part of the solid system are the supporting bridges for the cables, for they are often made of wood which absorbs moisture. Wood should never be used in direct contact with the lead sheath, as it invariably attacks it, oak being particularly bad in this respect. All organic matter should be kept clear of the lead, and anything likely to collect moisture should be excluded. Dome-shaped tiles are the best to use for protecting the troughing. The solid system is not a thoroughly practical system to use on a large scale, for it is hard to obtain good workmanship in our climate, while its rigidity leads to great disadvantages.

Armoured cables are usually laid direct in the ground with a protective covering of tiles or creosoted planks. The latter are more satisfactory, for they cannot be so easily displaced and turn the point of a pick better. The armouring is liable to chemical action in all but very dry soils, and it is for this reason that armoured cables are rather out of favour in this country. Attention has been directed to the improvement of the protective coverings on armoured cables with an endeavour to render these coverings as good as protection as the solid system, but with the very important advantage that the work can be carried out in the cable maker's shops under careful supervision and without any consideration of weather. The improved coverings adopted, and which are now provided on all armoured cables laid by the power companies operating on the north-east coast, consist first of a layer of a flexible bitumen compound $\frac{1}{16}$ in. thick, coated directly on the lead and served over all with two specially closely woven bitumen impregnated tapes. The cable is then served over these tapes with compounded jute yarn to form a bed for the armour, after which the armouring, either of steel tapes or wires previously passed through a bath of waterproof composition, is put on. This armouring is then served with jute yarn, passed through a bath of hot compound, and finally limewashed. The total cost of the specially protected armoured cables when laid is very little more than the cost of plain lead-covered cables laid on the solid system, and with this slight extra expense a much more suitable system is obtained.

In the design of extra-high-tension joints there are three essential points which require careful consideration: the jointing of the conductors, the insulation of the joint and the making of the joint watertight.

The author having given much attention to this question, recently devised a new method of jointing * which overcomes these disadvantages. The method of jointing, which is illustrated in Fig. 1, consists in using strips of flexible copper braid (*a*) which are laid longitudinally along the conductors, and which are bound down on to them lightly by a circular binding of copper wire (*b*), the joint being afterwards soldered. Joints of this type give a greatly increased electrical contact, as the flexible braid is compressed tightly into all the interstices of the conductor strand, and in proof of this it may be mentioned that a joint of this type made as in Fig. 1 and left unsoldered required one-third of a ton merely to pull one of

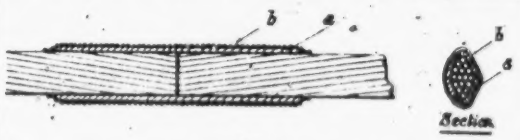

FIG. 1.

the conductors out of the braids. A similar joint again unsoldered was run up gradually to 7,000 amperes per square inch, its temperature rise being at all times lower than that of the conductor. Fig. 2 shows an alternative type of this joint for heavier conductors, which consists of more than three strands of wires. In this it will be noticed that the continuity of each strand can be maintained independently by separate layers of copper braid. The copper braid when soldered and dissected can scarcely be distinguished from solid copper, so thoroughly does it become filled with the solder, which it holds like a sponge.

Extra-high-tension joints may either be insulated by putting insulation on the conductors themselves or by spacing them apart and using the filling composition as the sole insulating material. It is of great importance in making the first type of joint to keep out air, and for this reason insulating tape alone gives a much better result than insulating tape combined with strips of mica. In the second type of joint a separator of ebonite, china or similar material is used and it is best not to employ insulating tape as well. Joints of either type may be filled in with oil or compound. Comparing the two types of joint the latter has the advantage that the conductors are well apart, and it is only a question of the right kind of

FIG. 2.

filling composition to use. A weak point, however, is the insulating separator which, in some cases, has caused breakdowns, owing to moisture creeping in.

A joint which the author considers more reliable than either of the two types already discussed, and one which, moreover, does not call for such great skill on the part of the jointer, is illustrated in Fig. 3. In this type of joint the insulation is provided by loosely fitting tubes, preferably micanite, which are sprung over the cores, the conductor joint being left bare inside them and the tubes overlapping some distance over the ordinary paper insulation at each end. The tubes, which are split on one side with a lap joint, are finally taped over their whole length with two layers of insulating tape to keep them together, and the three tubes are separated by star-shaped china pieces taped down to them, which keep them apart and centre them in the lead sleeve. This lead sleeve is then filled in with the insulating composition, either an oil or a viscous joint-box compound, preferably the latter—which can run into the tubes and all parts of the joint box. It is important to space the china separators as far as possible from the ends of the tubes, so as to increase the leakage path between cores and to earth. It will be seen that in a joint of

* Abstract of a Paper read before the Institution of Electrical Engineers.

* Patent No. 15,413, 1909.

this type the risk of puncture between cores is avoided, the workmanship is of the simplest description, and with a suitable joint box compound breakdowns are r[illegible] likely to be caused by air.

Such a compound must be viscous and of about the consistency of thick cream at ordinary temperatures. When heated it should run as freely as heated oil, so as to penetrate all crevices, and it must retain these features throughout its life, that is, it must remain a perfect mixture and not be liable to have its thinning constituents, oil and such like, separating out from the body of the compound, which consists usually of bitumen or resinous compounds. All oils must be freed from all moisture before use.

The usual causes of breakdowns, besides faulty workmanship, are external damage, chemical action, electrolysis, subsidences and earth movements, overrunning, vibration and pressure surges.

Breakdowns due to external damage have been rare in the author's experience, and would not average one case per annum over the past

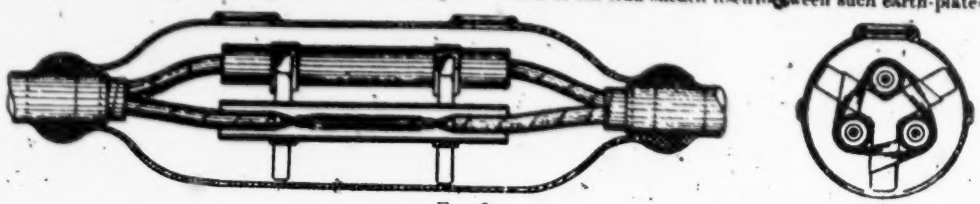

FIG. 3.

10 years from picks and crowbars. Chemical action, where care is taken in carrying out the work of laying the cables, should seldom cause any trouble. All material used in the work, such as pitch, oils, compounds, and linen tapes, as well as any suspicious water or soil encountered, should be submitted to a chemist for examination, and it may be remarked that in perhaps no branch of engineering work is there greater need for close co-operation between the chemist and the engineer.

Electrolysis on lead-covered cables is much more likely to give serious trouble before it is discovered, and is difficult to guard against, as the conditions which give rise to it may change frequently without any warning. Where bad cases of electrolysis have occurred it has generally been found to be due to excessive leakage from tramway undertakings or similarly from three-wire continuous-current networks. When this excessive leakage has been removed and the Board of Trade regulations complied with, electrolysis has been greatly minimised, if not altogether prevented. Much more can be done in this way than by earthing or insulating the lead sheath, as is frequently done, although these additional precautions will assist in preventing corrosion. The whole question is very much simplified on transmission cables by the cables being as a rule few in number and following definite routes, whereas on an extensive lead-covered low-tension network with all the lead sheaths bonded together and covering a large interconnected area it is a much more difficult matter to deal with it. Tests can be made at various points and evidence obtained of any conditions existing which are likely to cause electrolysis. Apart from this, there are at least two well-defined and opposite views on the question of the safeguarding of cable sheaths from the effects of electrolytic corrosion, which are earthing the lead sheath to earth-plates at frequent intervals and insulating the lead sheath from earth.

The principle underlying the first method is that a number of good metallic conducting paths should be provided at frequent intervals by means of which any current which gets on to the lead sheath may flow to earth instead of leaving the lead sheath through unintentional leakage paths, at which points corrosion will be set up. Unfortunately, a low-resistance earth is most difficult to obtain with any type of earth-plate, and this difficulty is further aggravated by the extreme difficulty of getting any permanent insulation of the lead sheath to earth along the remainder of the route with any of the usual systems of laying. Practically all lead sheaths, whether laid on the draw-in, solid or armoured systems, will test "dead earth" shortly after, if not at the time of laying. It is, therefore, a question of which path offers the lowest resistance to leakage currents, either the earth-plate or some other leakage path (such as at bridges, bends and ducts) between the lead sheath and earth. If the latter, then current may leave at such places and set up corrosion.

The second alternative view—that of insulating the lead sheath from earth—is claimed for such systems as the Howard asphalte solid system and also bitumen fibre conduits. How far such systems are successful in this direction it would be interesting to know from actual users and from tests made a few years after laying. It cannot be overlooked, however, that even if the insulation is not perfect with such systems a combination of them with earth-plates at intervals would prove of considerable advantage, as what is required is thus earthing the lead sheath at intervals is that the resistance of this lead sheath to earth should at any point along the route be considerably greater than that of the earth-plates, including the resistance of the lead sheath itself between such earth-plates.

Subsidences and earth movements, together with which the question of overrunning may also be considered, are much more frequent on solid laid cables than on either drawn-in or armoured cables, although none of these systems can be said to be altogether free from this trouble. Sometimes the opposite effect, viz., that of compression of joints or of cable bursts, is met with. In order to overcome troubles of this sort, the author has designed* an expansion type of joint which is illustrated in different types of sleeves in Fig. 4. The method of jointing the conductors is shown on a larger scale in Fig. 5, and consists of a guide tube (*a*) in which the conductor ends can slide freely, the electrical continuity of the conductors being maintained by strips of flexible copper braid (*b*), which are bound down to them at each side and to the guide tube in the centre in order to maintain the relative positions of the working parts. The insulation of the joint is on the lines already advocated and shown in Fig. 3, and need not therefore be described further. The joint is finally filled with a viscous joint-box compound, which does not interfere with the movement of the various parts. Joints of this type have been in use for about 18 months on several 20,000-volt cables on the power companies' systems in the Newcastle district,

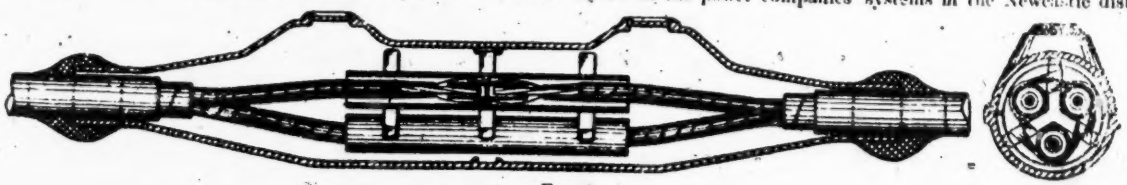

FIG. 4.

and have given very good results, no breakdowns of the joints or of the cables having occurred since their installation, although previous to this such breakdowns were very frequent. Joints opened up for inspection have shown movements of over 2 in. to have taken place, in some cases, in a few weeks. The latest joints installed provide for 6 in. movement in all, but joints can be made for much greater limits of movement if required. It is important that all joints in the affected area should be of the expansion type, and it is not sufficient

FIG. 5.

to insert such joints only at intervals, leaving ordinary non-expansion joints in between, as the latter will almost certainly be affected, notwithstanding the expansion joints on either side.

Again, transmission cables are at times loaded up to very high current densities, either in cases of emergency or in order to defer the incurring of heavy capital expenditure in laying additional cables, thereby causing expansion. The author strongly favours the inser-

* Patent 12,156, 1909.

tion of expansion joints on all transmission cables, which will enable such cables to be run up to any current density which the paper insulation will stand, with the certainty that the joints will not fail at a critical time. It should again be noticed that the solid system is not one which adapts itself to such expansion and contraction movements.

Power and railway companies who have cables laid alongside railway lines frequently experience breakdowns caused by the breaking of the lead sheath due to vibration from passing traffic. This source of trouble seems to be confined entirely to cables laid on the solid system, and takes place at the joints of the troughing. The remedy for this trouble is to use only armoured cables laid direct in the ground and at greater depth than usual if within, say, a distance of 4 ft. from the rails.

Resonance, fortunately, is not a very common cause of failure under normal conditions of working. Cables have usually a very large factor of safety (between 10 and 20, as a rule). For this reason it has been found quite practicable to switch long feeders direct on and off the system without using any charging devices. Nothing else has ever been done on the large power companies' systems on the North-East Coast, which were first put in operation in 1901, and it is therefore somewhat surprising to learn that cable-charging gear was still in use on some other large undertakings as recently as 1904-1905. When pressure surges are the cause of breakdowns of cables or of their joints, it is usually the result of a heavy short-circuit, which sets up oscillations in the system, and cables may break down due to a rise of pressure at some point often miles away from the short-circuit causing the disturbance. There can also be no doubt that the system persists in a condition which may give rise to further pressure rises for some time, as breakdowns often follow upon one another within a few days. Breakdowns on cables caused by pressure surges are usually quite characteristic and easily recognised when an instantaneous protective gear, such as the Merz-Price, is installed. The insulation is generally perforated as if drilled through, or, if the breakdown is in a joint, fine burnt cracks are found through the insulation.

In conclusion, it will be noticed that a large proportion of the breakdowns experienced arise from the use of lead for the outer waterproof sheath of cables. Of all the metals lead is probably the only one which can be conveniently used; but it would be an advantage to use a non-metallic waterproof sheath, if one could be obtained, which retained the great advantages of the present lead sheath without its disadvantages. Hitherto it has not been possible to obtain any such suitable material, and the problem is not an easy one to solve.

VACUUM METHOD OF FILLING CABLE JOINTS.

In view of the very great importance of extracting air from cable joints working at high pressures a method of filling the sleeves has recently been introduced by the Allgemeine Elektrizitäts Gesellschaft, and the apparatus here illustrated has been designed and manufactured by them. This firm have used the method for some time on a large contract for 30,000-volt cables in Berlin, and are also using it in this country on some 30,000-volt cables which they are at present

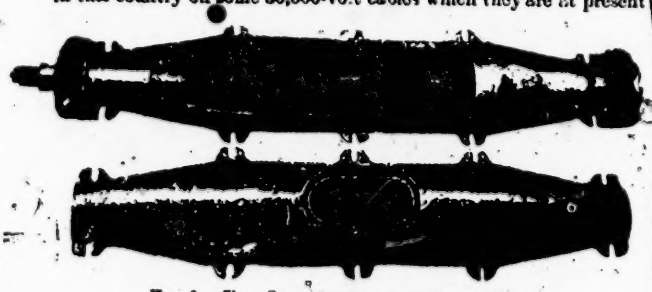

FIG. 1.—THE JOINT FITTED WITH PAPER TUBES.

laying for the Newcastle-upon-Tyne Electric Supply Co. At a recent meeting of the Institution of Electrical Engineers Mr. Chas. Vernier described the arrangement employed, and we are indebted to him for the following details and the accompanying illustrations.

The insulation of the joint consists of paper tubes made of the same paper as is used for the insulation of the cable. These tubes are also impregnated under vacuum at the factory with the same oil as is used for the cable. They are sent out ready for use in sealed tins filled with oil. Each core after jointing is left bare, and the paper tubes, which have previously been threaded on to the cores, are slipped back over the bare place. The three tubes on each core are themselves surrounded by a much longer paper tube, which encircles them and which lines the lead sleeve (*see* Fig. 1). The lead sleeve is wiped on in the usual way and the joint box is then filled. Figs. 2, 3 and 4 show the apparatus used. Fig. 2 shows the vacuum pump, which is driven by a small petrol engine of 1 B.P. capacity. The whole arrangement is very compact and portable.

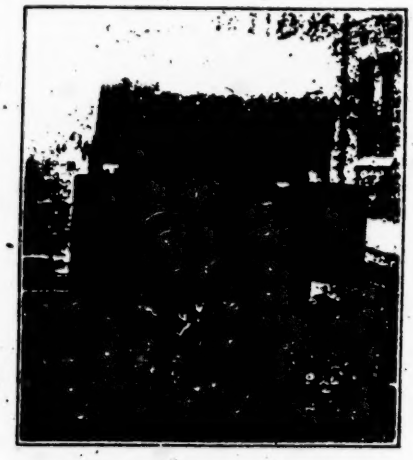

FIG. 2.—THE VACUUM PUMP.

The method of filling the joint is as follows (*see* Figs. 3 and 4): *J* is the joint, *E* is a funnel which contains sufficient oil rather more than to fill the lead sleeve, *F* is a reservoir with plate glass end, which enables the jointer to see what is going on, while *A*, *B*, *C*, *D* and *G* are controlling valves or cocks. To exhaust the joint, valves *B* and *D* are closed, and the valves *A* and *C* are opened to the vacuum pump. The vacuum, which can be read off on the gauge, is attained in about 30 seconds, and in a recent case reached 29·5 in. The vacuum is maintained in the joint sleeve for about 40 minutes, during which time the sleeve is kept warm by a blow lamp to drive off any moisture. This is readily done owing to the fact that moisture evaporates at very low temperatures under vacuum, at about 40° C. for 28 in. vacuum.

To fill the joint the funnel *E* is filled with the insulating oil. This

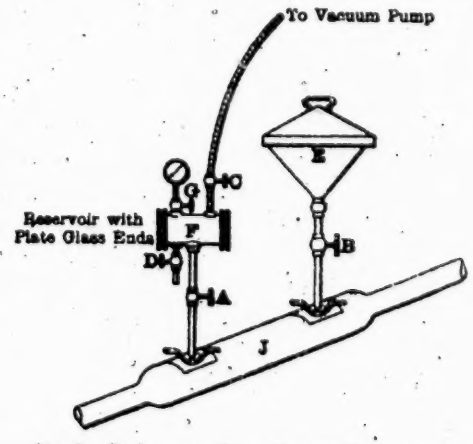

FIG. 3.—DIAGRAM OF JOINT FILLING EQUIPMENT.

oil is exactly the same oil which is used to impregnate the cable, and at ordinary temperatures is not unlike vaseline in consistency, but pours as freely as a liquid when heated. The oil is first heated up until all moisture is thought to be driven off, and then is allowed to cool down to about 110° C., at which temperature it is poured. Valve *B* is then opened slowly until the oil fills the joint and can be seen through the glass windows rising up into reservoir *F*. The vacuum pump is kept running the whole time, and the level of the oil in reservoir is controlled by the valve *B*.

* An abstract of this Paper is given on p. 940 of this issue.

It is generally found that the oil as it rises in the reservoir *F* is covered with a deep layer of froth, due to moisture, which illustrates in a very practical manner the great difficulty of extracting all the moisture from oils by the mere application of heat.

Valves *A* and *B* are then closed, and funnel *E* and reservoir *F* are uncoupled from the stand pipes. A small funnel containing a little oil is then screwed on to each stand pipe, and valves *A* and *B* are

Fig. 4.—The Joint Filling Apparatus.

re-opened. The oil in these funnels is kept heated for about 12 hours until the oil in the joint has cooled down, for the purpose of making up any shrinkage in cooling. The stand pipes are then dismantled and the plugs wiped into the filling holes.

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DEFENDANT'S EXHIBIT A A

Jan. 12, 1932. P. TORCHIO 1,841,320

ELECTRIC CABLE

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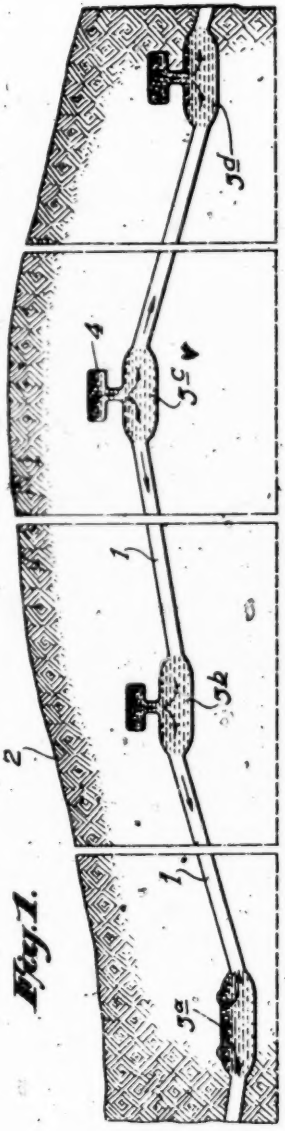

Fig. 1.

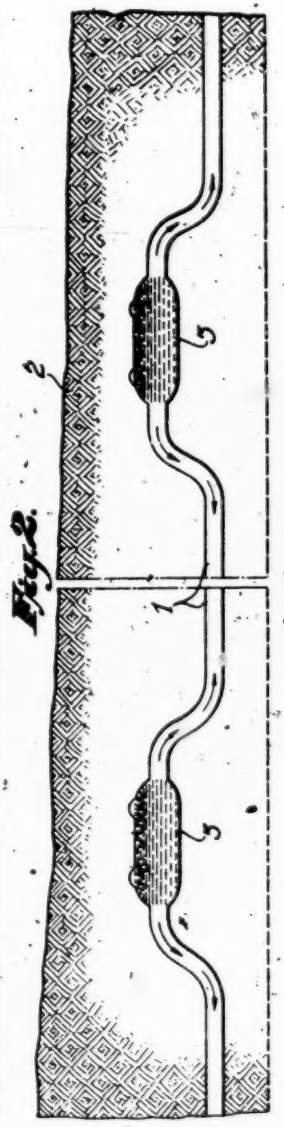

Fig. 2.

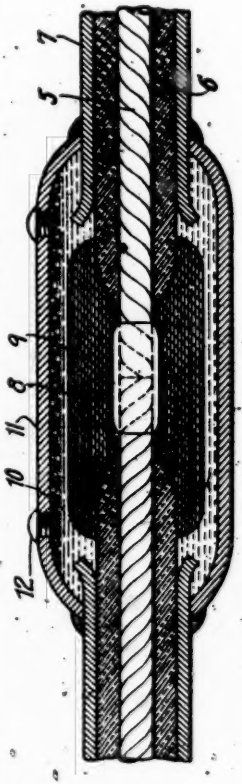

Fig. 3.

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By His Attorney
W. Anthony Alessa

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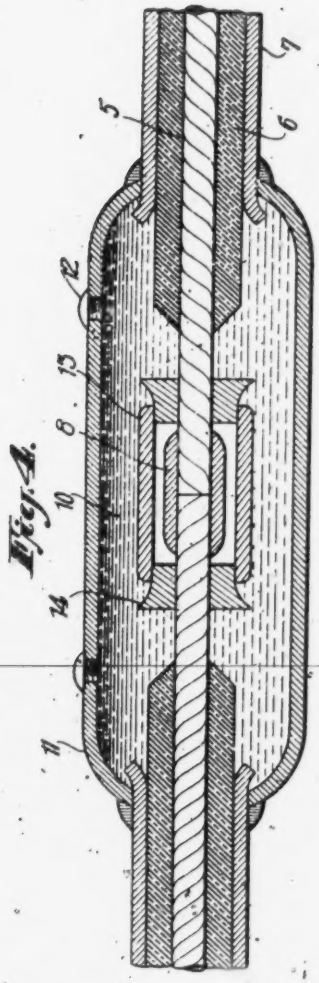

Fig. 4.

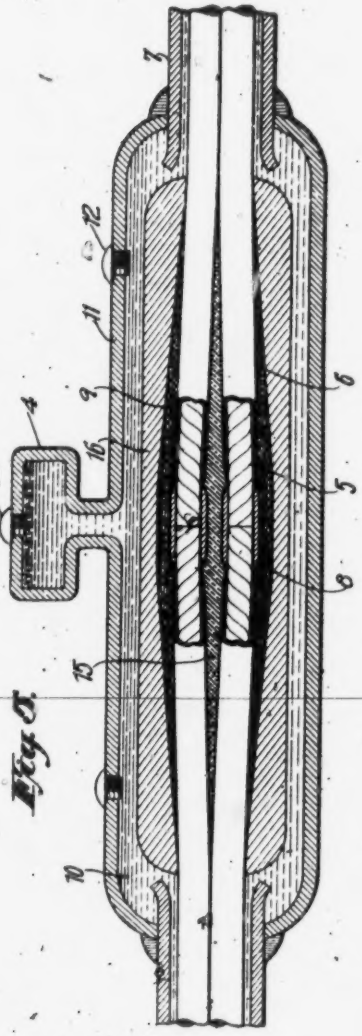

Fig. 5.

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ELECTRIC CABLE

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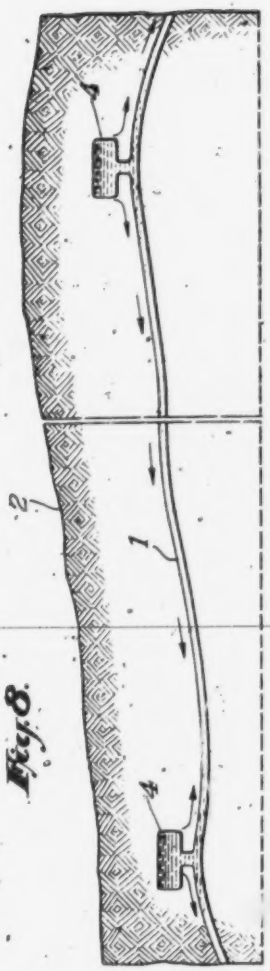

Fig. 8.

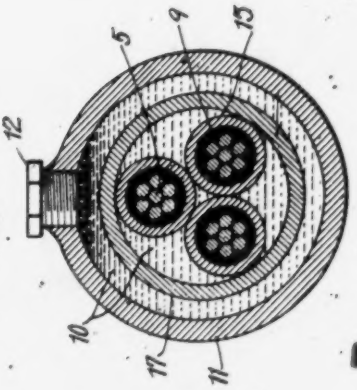

Fig. 7.

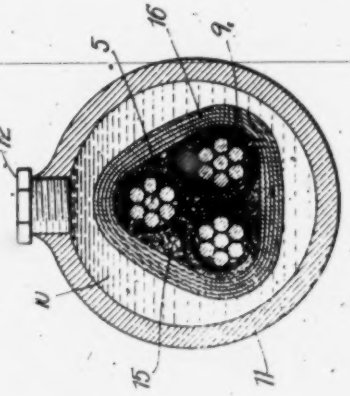

Fig. 6.

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By His Attorney
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Patented Jan. 12, 1932

1,841,320

UNITED STATES PATENT OFFICE

PHILIP TORCHIO, OF LAWRENCE PARK, BRONXVILLE, NEW YORK

ELECTRIC CABLE

Application filed June 25, 1925, Serial No. 39,439. Renewed July 15, 1931.

In my Patent No. 1,172,322 I have described a joint for electric cables surrounded by a lead sheath containing insulating oil or similar liquid.

I have discovered that by the use of a sufficiently light oil, one which flows more easily than the fluids generally used for impregnation of cables by manufacturers, and by taking advantage of gravity or by the use of artificial pressure, I can maintain the insulation in good condition not only at the joint but also for considerable distances beyond the joint. In fact the joints may be at such distances and the cable of such construction and laid along such grades as to permit the passage of the oil and the maintenance of the insulation throughout practically the entire length.

The accompanying drawings illustrate an embodiment of the invention.

Fig. 1 is a diagrammatic elevation of an underground cable with joints at different levels;

Fig. 2 is a similar view of a cable with joints at about the same level;

Figs. 3, 4 and 5 are longitudinal sections of different styles of joint.

Figs. 6 and 7 are cross sections of different styles of joint.

Fig. 8 is a diagram illustrating a modification.

Referring to Fig. 1, the cable 1 follows approximately the level of the surface 2 of the ground. The sections of cable are joined, usually at manholes, by joints 3. To distinguish the different levels in Fig. 1, the joints are marked 3^a, 3^b and so forth. On the upper side of each joint casing there is a reservoir 4 shown in Fig. 1. Or the casing at the joint may be made large enough to dispense with a separate reservoir.

The thin oil introduced at the joints permeates not only the insulating material but also the cable ends. It also enters the interstices between the strands of the usual stranded copper conductor and any interstices in the insulating material, and by capillarity and pressure, particularly where assisted by gravity, travels along the length of the conductor or conductors to a considerable distance beyond the joint. As the oil trave along the conductor, it permeates the su rounding insulation. The supply of oil at the joint is sufficient to make up any deficiency in the sleeve caused by the absorption and breathing of the cable, and also any deficiency in the cable beyond the joint caused either by inherent dry spots and wrinkles or by the breathing of the cable. This breathing is an expansion under increased load and temperature and a contraction which is incomplete in the surrounding insulation, leaving voids or wrinkles in the insulation, which results in a lowering of the dielectric strength of the insulation.

In such an installation as shown in Fig. 1 the oil introduced at the joints is fed by gravity from the higher levels to the lower. On such a line inspection of the joints has shown a necessity for refilling those at the higher levels, as 3^b and 3^c from time to time, but no necessity for refilling those at the lower levels as 3^a, this joint and the adjacent portions of the cable being kept full by pressure from the higher reservoirs. There is in fact no need for a reservoir such as 4 on this lowest joint and even the lead sheath around it does not need to be large enough to carry any substantial surplus of oil.

The refilling of the reservoirs or receptacles at the higher joints from time to time thus maintains an excess of oil and keeps the entire cable including the joints at lower levels in good condition. The supply of oil to the new cable is of great importance because in the handling and laying thereof the insulating oil applied at the factory is apt to migrate from certain parts and to leave voids; and because voids and wrinkles are produced to some extent in original faulty wrapping and in bending of the cable as laid. And the replenishment of the oil supply through the joints is important in filling the voids and supplying the deficiencies created by migration and breathing which take place during use of the cable. By my method of supplying and maintaining oil, failures from improper insulation are eliminated between the joi[illegible] at the joints.

Fig. 2 [illegible] invention applied to a

cable 1 which is practically level, the joints 3 being elevated above the intermediate portions of the cable so that the oil supply maintained in the joint sleeves will flow by gravity to the intermediate parts of the cable. No separate reservoirs are shown for the joint sleeves in this figure, the sleeves being large enough to carry the required reserve of oil.

The joints illustrated in detail are of known types. The invention may be applied to cables and joints of these and of various other styles. In Fig. 3 a stranded conductor is shown at 5 surrounded by factory insulation 6 and a lead or other metallic sheath 7. The bared ends of the cable are wrapped in a connector 8 and a wrapping 9 of paper or cambric about which is the supply of oil 10 in the lead or other metal sleeve 11. The oil is introduced through holes in the sleeve which are afterwards closed by plugs 12. Any suitable apparatus may be used for introducing the oil under sufficient pressure to secure the desired initial distribution of it; after which a mere refilling from time to time will serve the desired purpose as above stated.

According to Fig. 4 the bared ends of the cable held within the connector 8 are surrounded by a tube 13 of paper or mica closed at the ends by spacing blocks 14 of conical shape.

According to Fig. 5 there are three conductors 5 in the cable. They are separately connected at their bared ends by connectors 8, separated by a filler 15 of paper or jute and surrounded by a wrapping 9 of paper or cambric and a second wrapping 16 and then by the oil 10 in the lead sleeve 11 which is surmounted by a separate reservoir 4. An extra supply of oil is desirable in a case, like this, where a joint is made in a three-conductor cable.

Figs. 6 and 7 are cross-sections through joints of different types for three-conductor cables. The cables 5 are of the usual seven strands laid up in spirals. Between the usually circular strands there are spiral interstitial spaces constituting channels running the full length of the conductor and affording passages for the flow of the oil. According to Fig. 6 each conductor is surrounded by a wrapping of paper or cambric 9, the spaces between the conductors are filled with a filler 15 of paper or jute, and a second wrapping 16 of paper or cambric is arranged around the three conductors.

According to Fig. 7 each conductor 5 is carried in a wrapping 9 and in a separate joint tube 13 of paper or mica, and the three conductors together are enclosed in a larger tube 17 of similar material. The oil 10 fills the space within the tube 17 as well as that within the outer shell 11.

It will be seen from the above description that the invention is applicable to cables of one or more electric conductors and to cables with wrappings and sheaths of various materials and designs. The very light oil proposed will travel great distances. The shell of the joint will generally be of lead hermetically sealed at both ends to the lead sheath of the cable. It may be of other materials and construction, however, as long as it will prevent the escape of the oil. It may be made with its inner diameter only great enough to fit the outer diameter of the wrapped joint, or it may have a clear space for a reserve or excess of oil or may carry an extra oil reservoir as above explained.

Different designs and arrangements involving the invention may be adopted according to the profile of the route of the cable run. But in all cases the layout is best designed to provide sufficient total passageway along the cable and a sufficient quantity of oil of the required fluidity at the joints to flow into such passageways, to be absorbed by the insulation and to fill the wrinkles, voids and clearances existing in the cable as laid and occurring in its use.

The invention is most readily applied to existing cable systems at joints in the cable. But the thin insulating liquid may also be introduced where there is no break in the continuity of the conductor. It is only necessary to make a hole through the sheath and introduce a thin insulating oil in such volume and under such circumstances of gravity or artificial pressure as will cause it to flow into the interstitial spaces and to travel along the conductor to a point where a supply of such oil is maintained from another point of introduction. Fig. 8, for example, shows a theoretical line of cable 1 without joints but with reservoirs 4 at high points which feed oil continuously in both directions by gravity.

The oil used should have practically no viscosity, or so little as not to interfere with its flowing easily along the cable. An example of an oil which I have used with success is oil having a density at ordinary temperatures of about .870.

Various modifications may be made by those skilled in the art without departing from the invention as defined in the following claims.

What I claim is:

1. An electric conductor comprising a cable made of strands laid in contact with each other between which are spiral interstitial spaces, said cable having a pervious wrapping applied directly and closely to the cable without any intervening space except such as may be due to the shape of the strands, such wrapping being impregnated with an insulating filling compound, an impervious outer sheath closely fitting said pervious wrapping, an insulating liquid in communication with the interstitial spaces of the cable and of the pervious wrapping, and

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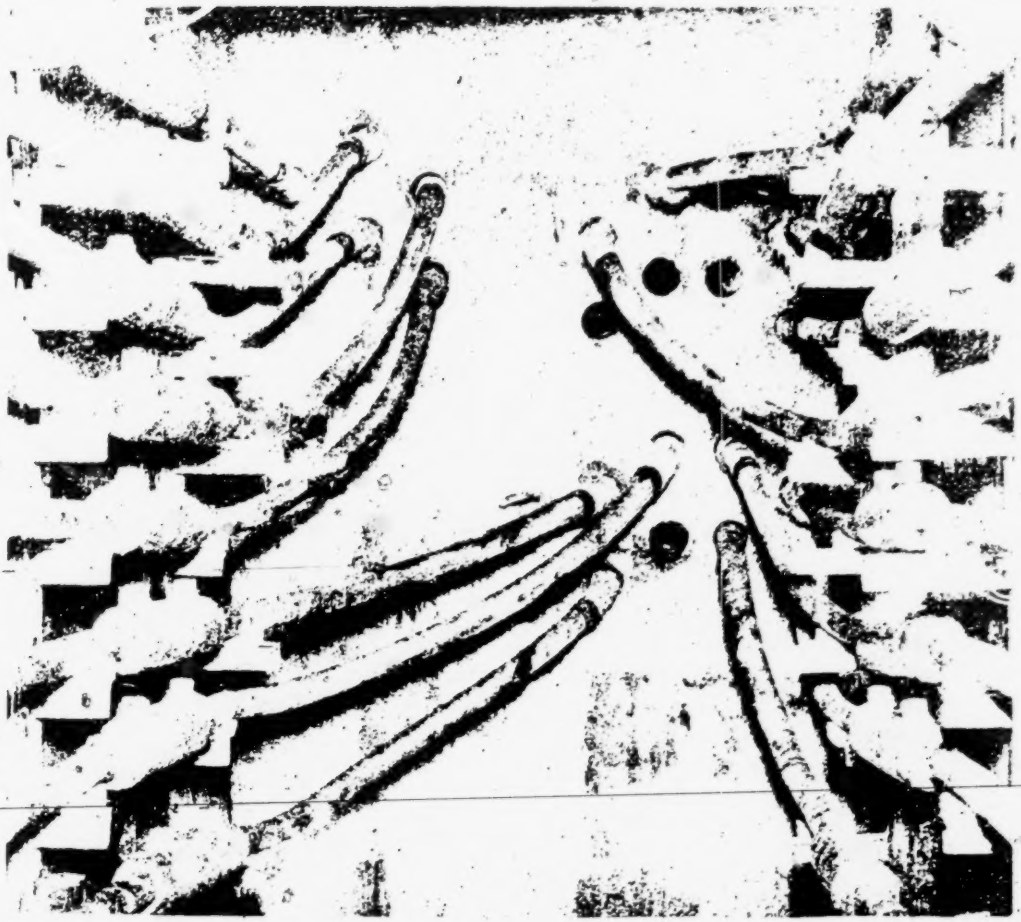
means for carrying an excess of such liquid said liquid being more fluid than the compound used for impregnation of the pervious wrapping and so fluid as to travel along such interstitial spaces and to enter any voids in the insulation.

2. An electric conductor comprising a cable made of strands laid in contact with each other between which are spiral interstitial spaces, said cable having a pervious wrapping applied directly and closely to the cable without any intervening space except such as may be due to the shape of the strands, such wrapping being impregnated with an insulating filling compound, an impervious outer sheath closely fitting said pervious wrapping, an insulating liquid consisting of oil with a density at ordinary temperatures of about 0.870 in communication with the interstitial spaces of the cable and of the pervious wrapping, and means for carrying an excess of such liquid, said liquid being more fluid than the compound used for impregnation of the pervious wrapping and so fluid as to travel along such interstitial spaces and to enter any voids in the insulation.

In witness whereof, I have hereunto signed my name.

PHILIP TORCHIO.



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THE ELECTRICAL WORLD's annual tabulation of operating data on the major electric power systems in the United States and Canada will be available April 30.

This tabulation will include statistics for all systems having an output exceeding 100,000,000 kw.-hr. in 1926; it embraces 150 systems, as against 129 for 1925. The number of electric service systems in the United States, of which there were 110 in last year's table, has grown to 124, despite the disappearance of several names from the list because of consolidations. From seven last year the Canadian companies have now come up to ten; there are fifteen railways in place of twelve; and a Mexican company appears for the first time.

The data account for more than four-fifths of the energy generated by the electric light and power industry in this country. The old figure was 80 per cent; this year the proportion will probably be even greater. The output of the largest system exceeded 4,000,000,000 kw.-hr.

The compilation was made possible by the 100 per cent co-operation of utility companies and systems coming within the designated classification. Inquiries were sent to cover all companies known or believed to be in the 100,000,000 kw.-hr. group; in every case, without exception, definite replies were received.

As before, there will be two tables, one giving detailed data for 1926 and containing more than 3,500 separate items, the other—of about equal size—affording comparative information for earlier years back to 1918.

Advertising Index—Alphabetical, 106; Classified, 100, 102, 104; Directory of Engineers, 54, 55; Searchlight Section, 56-6

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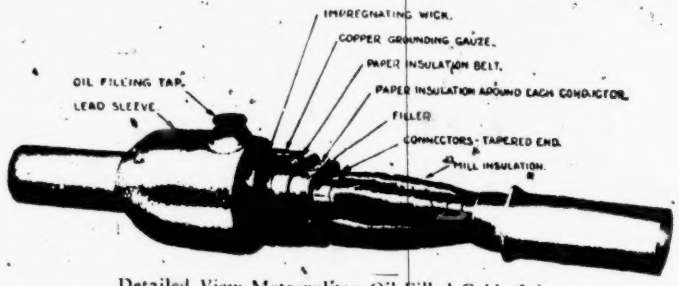

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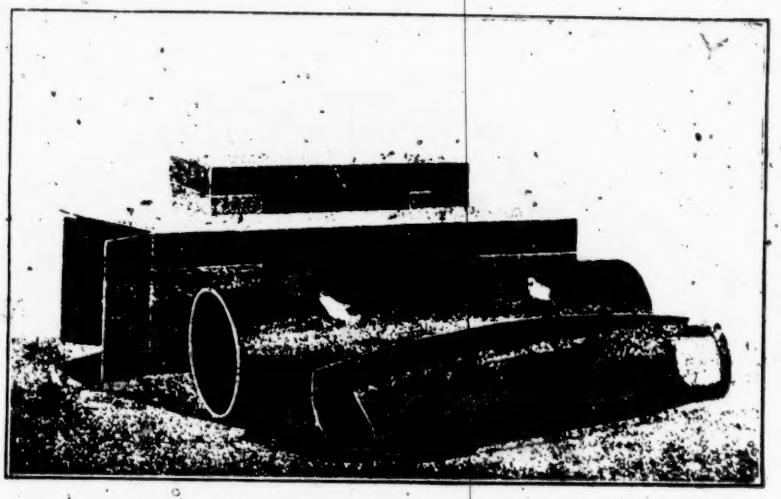

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The Expanding Science of Industrial Marketing

WHEN wages were low and time was cheap, men didn't have to be particular. Our grandfathers ran their industries largely by tradition and by rule o' thumb. And people lived that way also. Because labor and things did not cost much, the gentle art of splitting pennies had not yet become an economic science.

But the ways of life have changed, and machinery and power, scientific management and high-pressure organization—modern efficiency, in a word—have all been seized upon by industry to reduce production costs per unit as men have steadily advanced the price of their service. Better planning, better preparation, better processes and better operation have all been invoked to meet the rising economic stresses.

The sales methods of industry have not kept pace with this refinement in the science of production. Salesmen are temperamental, and sales managers have most of them continued to broadcast their efforts, building up their sales rather by the intensifying of publicity and personal selling than by more accurate analysis of market possibilities and more purposeful advertising and merchandising.

The Electrical World, through the counselors' staff of the McGraw-Hill Company, during the last two years has made a very fundamental contribution to the now expanding science of industrial marketing. An exhaustive research has been conducted into the actual buying habits of industry. Out of this have been crystallized certain guiding principles of market determination that lead to the development of logical channels of approach and appeals that influence, and these are proving of tremendous practical benefit to many manufacturers in the solving of the complex problems involved in sales to industry.

Something of this new philosophy of industrial marketing has been put into a book, and it is being interpreted also in a series of full-page advertisements that are right now appearing in the leading newspapers of the more important cities of America and in the McGraw-Hill publications (see advertising pages 60 and 61). A copy of this book and reprints of these advertisements will be gladly sent to any electrical manufacturer who may desire to see them.

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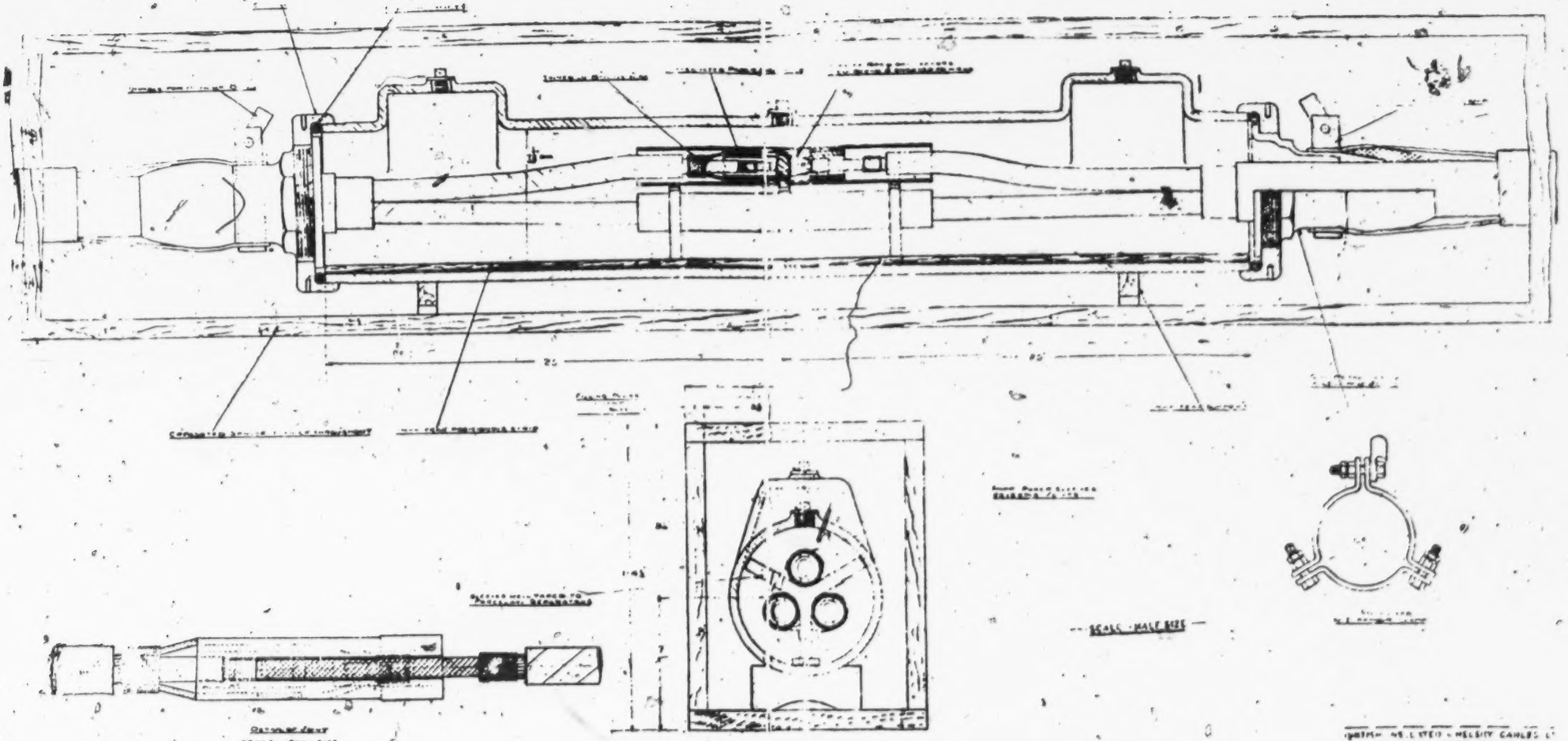

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[fols. 854 & 855] IN UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK

ELECTRIC CABLE JOINT COMPANY, Plaintiff,

vs.

BROOKLYN EDISON COMPANY, INC., Defendant

July 13, 1932.

Appearances:

Usina & Rauber, Esqs., Solicitors for Plaintiff, by D. A. Usina, Esq., of Counsel.

Monroe & Byrne, Esqs., Solicitors for Defendant, by Charles Neave, Esq., and J. D. Monroe, Esq., of Counsel.

OPINION, INCH, D. J.

INCH, J.:

Plaintiff brings this suit for alleged infringement of patent by defendant. The patent is one issued in the United States to Philip Torchio, February 22, 1916, No. 1,172,322. It was applied for March 13, 1915.

The patent has several claims but at the trial plaintiff relied on but one, to wit, No. 4. This claim is as follows:

"4. An electric cable, comprising a sheath, in a line con-
[fol. 856] ductor having a joint, a body of pervious insulating material inclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, inclosing the same and hermetically united at its ends to said cable sheath, a receptable communicating with the interior of said sleeve, and an insulating fluid adapted to permeate said pervious body contained in said receptacle and the space between said body and said sleeve."

The inventor Torchio in the patent asserts that he had invented a certain new and useful Improvement in Protected Devices for Electric Cable Joints and that by his invention leakage of current at a joint in an electric line conductor and more particularly at the joints in the line conductor of cable is prevented.

At the time of his application for the patent Mr. Torchio was the chief electrical engineer of the New York Edison Company and was thoroughly familiar with the difficulties experienced by that company in handling heavy currents of electricity by means of high tension cables which naturally had to be joined at convenient places.

Occasionally, heavy overloads of current produced local stresses which in turn developed cracks and voids and the insulating strength with which the cable was provided was lowered, particularly at these joints, the result causing serious damage and interruption of service.

The air in these breaks or cracks became ionized, that is, became, in a sense, conductors, and much thought and time [fol. 857] had been spent in an effort to find some means which would prevent this trouble where extremely high voltage was necessarily used by concerns like defendant and must be safely distributed.

Murray filed a Disclaimer, which is as follows:

Disclaimer

"1,172,322.—Philip Torchio, New York, N. Y. Protective Device for Electric-Cable Joints. Patent dated February 22, 1916. Disclaimer filed February 11, 1927, by the assignee, Thomas E. Murray.

Hereby makes disclaimer of the improvement described except for electric cables which comprise a line conductor, insulating wrappings permeated with insulating compound and a sheath of flexible inelastic metal constituting a unitary product of manufacture and commerce which is portable and capable of being drawn through conduits; and except as to an insulating liquid which is fluid at ordinary working temperatures of such cables and in quantity sufficient to supply at all times the demands made by the cable in use, and by the joint. (Official Gazette, March 1, 1927.)"

The filing of this disclaimer presents no difficulty. Permutit Co. vs. Harvey Co., 279 Fed. 713. Garson vs. American etc., Co., 4 F. (2d) 463-469. Permutit Co. vs. Wadham, 13 F. (2d) 454. Sachs etc., Co. vs. Hartford Co., 47 F. (2d) 743.

[fol. 858] It also appears that this patent has been owned by various parties. First by the inventor, then by an of-

ficer of the defendant (Murray), who owned it from 1922 to 1927, then by the Metropolitan Device Corporation, and finally by plaintiff, who became possessed of it on April 18, 1931.

While the Metropolitan Company owned it there is evidence, from correspondence between that company and this defendant, that what was then considered the real invention was the "gauze stocking" of Torchio, which he placed about the wrappings of the joint, and the dense body of the insulating compound, neither of which is used by the defendant at the present time and as to which defendant also claims an estoppel. However this point need not be considered for reasons subsequently stated in this opinion.

As to the defendant, while it is the nominal party defendant, it admits that the General Electric Company and the General Cable Corporation are contributing to the defense.

One other very important matter must be stated before coming to the merits.

Both this patent and the Disclaimer have been before the Circuit Court of Appeals, for the Sixth Circuit. That court reversed the decree of the District Court (Judge Westenhaver) and held that Claims 3 and 4 of this patent were valid and infringed.

While that suit, before that court, was between said Metropolitan Device Corporation, then owner of the patent, and the Cleveland Electric Company, the mere fact [fol. 859] that the patent has thus been passed upon by this high court and held valid would be sufficient for me to pass to the other defense, that of infringement. But it is apparent that that high court did not have the advantage that this court now enjoys of having before it the more thorough search of the prior art which the industry of the present counsel has produced. It is equally apparent that the distinguished and experienced trial judge even without this information had held the claims invalid and that the higher court, although reversing his decision, indicated the question presented was not beyond argument, stating: "We think it was somewhat beyond the skill of an expert and amounted to patentable invention."

The evidence, which, in a sense, may be considered now, as shown from the reading of the opinions and a consideration of the prior art as now presented, and to which reference will be made, compels me to reach a different con-

clusion. This I am obliged to do after giving the utmost consideration to such decision. Mast & Co. vs. Stover Mfg., 177 U. S. 485.

An inventor must not only be an inventor but he also must have made a discovery. Thompson vs. Boisselier, 114 U. S. 1.

Coming now to the patent under consideration that is, Claim 4, which has already been set forth, we find that Claims 3 and 4 differ only by the addition in Claim 4 of the words "receptacle communicating with the interior of said sleeve" and the statement that the insulating fluid is contained in "said receptacle and space between the said body and said sleeve."

Plaintiff in effect contends that Torchio invented a cer- [fol. 860] tain new and useful combination of elements, composing a new protective device for these electric cable joints, which combination consists of means for the immersion of the joint in an insulating oil, fluid at working temperature, and adapted to permeate the pervious wrappings of the joint, together with a sleeve of impervious material, inclosing the wrappings, together with a reservoir for the oil as shown in the patent drawings.

That this invention was a discovery.

That the inventor discovered the use of an oil of the nature described and the so-called "breathing" of the cable, caused by the expansion and contraction thereof as the heavy loads of electricity passed through, and that a reservoir containing the excess oil was needed for the reason that the movement of the current and its effect, gradually tended to exhaust the oil, thereby forming voids and otherwise destroying the insulation.

There is no doubt that the use of oil and the effect of this "breathing," and the necessity for having a supply of oil on hand, results in a safer and better joint. But the question is, was Torchio the inventor of this combination?

There is testimony that indicates that Torchio was not seeking oil of the density now claimed for him by plaintiff but on the contrary, although he knew of its use, was seeking a compound of greater density, and, in that sense, was endeavoring to avoid such fluid compounds in these high voltage cable joints.

However this may be, it clearly appears, that prior to his application for a patent he had gone abroad to see and

[fol. 861] study the progress of other companies in this matter of high tension cables. That likewise Mr. Rabe, at that time connected with the New York Edison Company had reported to him as to high tension cable insulations at Boston, in this country.

In other words, that he was familiar with the subject from these and other sources and of course must be assumed to have been familiar with the prior art at the time of his application.

The fact that later, in 1925, Torchio applied for and recently received another patent relating to the use of light oil, is not necessarily material here, as we are considering solely the alleged new combination claimed in the patent in suit in Claim 4.

As I have already stated much of the prior art has not been before the court until this trial. I shall mention briefly but three examples.

The Geipel British Patent No. 11,280, applied for June, 1894, granted December 8, 1894, relates to an alleged improved method of joining electric conductors and among other things the inventor states: "After the joint is thus made the box may be filled with a suitable insulating material as for example, oil, wax," etc. He then states that he deemed oil unsuitable and prefers wax where rubber insulation is used but he goes on to say, that, "with paper or jute insulating conductors oil may be used." (Lines 22-28, page 1, of patent.)

The Lemp Patent, U. S. No. 534,802, applied for December 3, 1892, granted February 26, 1895, relates to a construction of a transformer adapted to furnish heavy cur-[fol. 862] rents and in this connection the inventor had the idea of a "liquid tight tube" and the immersion of conductors in oil in this receptacle or tube the inventor stating that, "when the secondary has been placed around the primary and the proper liquid tight joints formed as described, it is filled with oil, connection with a reservoir or supply pipe being maintained to allow for expansion under increase of temperature."

He further states: "Preferably I employ some heavy cylinder oil that shall stand as high a temperature as a 100 degrees centigrade."

In accordance with this, Lemp has 12 claims a typical one being that No. 11 which is "the combination, substan-

tial as described, in a transformer, of a tubular secondary inclosing the primary and filled with oil and an oil reservoir or stand pipe connected with said tubular secondary, as and for the purposes described."

Finally the disclosure of C. Vernier contained in a very detailed paper read before the Institution of Electrical Engineers, in England, on March 9, 1911, about four years before Torchio applied for a patent. This paper was entitled, "The Laying and Maintenance of Transmission Cables." It referred to high tension cables, that is those exceeding 20,000 volts. The defendant uses as high as 27,000 to 33,000 volts. This paper was likewise published, the same year, in this country.

It represents a printed publication duly distributed. Rosenwasser vs. Spieth, 129 U. S. 47. See Britton vs. White Mfg. Co., 61 Fed. 96; Keene vs. New Idea Co., 231 Fed. 701; Fulton Co. vs. Bishop etc. Co., 284 Fed. 774.

[fol. 863] The information given was precise enough to guide a person skilled in the art. Seymour vs. Osborne, 78 U. S. (11 Wall) 516; Cawood Patent, 94 U. S. 704; Downtown vs. Yeager Milling Co., 108 U. S. 466; Eames vs. Andrews, 122 U. S. 66.

In this paper, written and published four years before Torchio, Vernier says: "The satisfactory joining of cables is the most important operation in connection with cable laying * * * badly designed joints * * * will prove a sure and constant source of trouble. Joint breakdowns are however inexcusable at the present age."

He then proceeds to discuss what he considers to be three essential points. First the joining of the conductors. Second the insulation of the joint. Third the making of the joint water tight.

It is his discussion of the second point, to wit, the insulation of the joint that we are particularly concerned with in this case.

Vernier illustrates and describes in his paper a very similar arrangement to Figs. 5 and 6 of the Torchio drawings. He states that "joints of either type may be filled with an insulating oil or a joint box compound (of a solid or viscous nature)."

He then states that some engineers object to "oil" because they fear that it would be absorbed but goes on to state that he had "yet to meet a case where a breakdown has occurred from this cause."

He further states that he "considers it important that a joint insulated in the manner shown in Fig. 12 should be filled with an 'oil'."

And if not "oil" as in the sample joint numbered Fig. 13, then some "viscous" compound of "about the consis- [fol. 864] tency of thick cream" at ordinary temperatures which, when heated, will run as freely as heated oil.

It is hard for me to believe that with this detailed paper before him that a competent electrical engineer would not have before him sufficient guidance and suggestion on which to bring about the particular assembly now the subject of the claim in the patent before me.

It seems to me therefore that laying Claim 4 and this Vernier disclosure side by side we find substantially the same thing. None of this prior art was before the high court when it declared this claim to be valid.

Thus we find that the elements of the combination were not only old but produced no new results not contemplated by the prior art.

Taking this view of the matter it is not necessary for me to discuss the question of infringement by this defendant as to which there may well be serious doubt for the reason that the reservoir of defendant differs materially and it did not use the "gauze stocking." Nor is it necessary for me to pass on the questions of laches or estoppel.

It is my opinion, with the due deference for, and after giving the most careful consideration to, the high court mentioned, that Claim 4 of this patent is invalid in view of the prior art.

This being so the complaint must be dismissed.

Robert A. Inch, U. S. D. J.

[fol. 865] In United States District Court, Eastern District of New York

[Title omitted]

Findings of Fact and Conclusions of Law

The Court makes the following findings of fact and states separately its conclusions of law thereon.

Findings of Fact

1. This suit was commenced on or about February 23, 1931, and is based on the alleged infringement by defend-

ant of United States patent No. 1,723,322, issued to Philip Torchio February 22, 1916, applied for by said patentee March 13, 1915.

2. Upon the trial of this cause plaintiff limited and confined its claims and evidence to claim No. 4 of the patent.

3. The patent in suit, since its issuance, has been owned: (1) by Philip Torchio from February 22, 1916, to June 10, 1922; (2) by Thomas E. Murray from June 10, 1922, to February 11, 1927; (3) by Metropolitan Device Corporation [fol. 866] from February 11, 1927, to November 1, 1930; (4) by Arthur J. Perfler from November 1, 1930, to April 18, 1931, and (5) by Electric Cable Joint Company, plaintiff, from April 18, 1931, to date.

4. February 11, 1927, Thomas E. Murray, as assignee of the patent in suit, filed a disclaimer, a copy of which is set forth in the opinion herein.

5. Thomas E. Murray, owner of the patent in suit, as aforesaid, was a director and member of the executive committee of the board of directors of defendant from February 24, 1913, to June 27, 1922, and again from February 24, 1925, to November 27, 1928, and was president of Thomas E. Murray, Inc., a New York corporation, employed by said defendant in a consulting engineering capacity in the construction and equipment of its Hudson Avenue generating station from June 28, 1922, to about February 24, 1925.

6. The General Electric Company and General Cable Corporation are contributing to and participating in the control of the defense herein.

7. The patent in suit and the disclaimer were before the Circuit Court of Appeals for the Sixth Circuit in Metropolitan Device Corporation v. Cleveland Electric Illuminating Company, (36 Fed. [2d] 477), wherein the Circuit Court of Appeals reversed the decree of the District Court dismissing the complaint, and held that claims 3 and 4 of the patent were valid and infringed.

[fol. 867] 8. The sleeve of the electric cable joint which was found by the Court of Appeals to infringe in the Cleveland case, was filled with an insulating compound normally of the consistency of vaseline or jelly.

9. Much evidence relating to and disclosing the prior art, which was not in the record before the Circuit Court of Appeals for the Sixth Circuit, in the Cleveland case, has been presented here by defendant, which evidence distinguishes the case here presented from that which was before said Circuit Court of Appeals.

10. Torchio, the patentee, does not purport, in the patent in suit, to have made any change in electric cable construction, installation or operation, nor to have created joints in high tension electric cable, nor to have been the one to introduce pervious wrappings at the joints, nor to have been the first to fill the joint sleeve with an insulating material of some sort.

11. Prior to and at the time of his application for the patent in suit, Mr. Torchio was the chief electrical engineer of the New York Edison Company, and was thoroughly familiar with the difficulties experienced by that company in handling high voltage currents of electricity by means of high tension cables, which cables naturally had to be jointed at convenient places. These difficulties arose at the joints where cracks and voids developed in the insulating compound; with high voltage current air in these cracks and voids became ionized and thereby became a conductor of electricity permitting the same to escape [fol. 868] from the copper conductors in use for its transmission, causing serious damage and interruption of service.

12. Prior to the making of his alleged invention, Torchio had gone abroad to see and study the progress of other companies in the matter of high tension cable joints, and, in Berlin, had inspected the 30,000 volt cable system there in use and a high tension joint was made up for his inspection, of which he made a sketch while inspecting the work. He there observed that the cable joints were enclosed in lead sleeves hermetically connected to the lead sleeve of the cable by means of wiped joints, and that the sleeve of the joint was filled with a compound which at normal temperature was semi-liquid, and similar to the compound used for saturation of the cables.

13. Also prior to the making of his alleged invention, Torchio sent Rabe, one of his associates and assistants,

in the employ of New York Edison Company, to Boston, to observe the process of making high tension cable joints by a British concern then engaged in installing some twelve miles of 15,000-25,000 volt cable there. Rabe did this and early in August, 1914, reported to Torchio, in writing, that some of the cable was of three conductors, paper-wrapped and sheathed with lead. A detailed description of the method of making the joint and of the vacuum process of filling the same was given in Mr. Rabe's report, and Torchio was informed thereby that the joints were filled with an insulating compound, which at ordinary temperature was about the viscosity of molasses.

[fol. 869] 14. Torchio, in his work prior and leading up to the application for the patent in suit, was not seeking a joint insulating compound of the fluidity now claimed for him by plaintiff, but, on the contrary, although he knew of the use of such fluid compounds, was seeking a compound of greater density, and, in that sense, was endeavoring to avoid the use of such fluid compounds in these high voltage cable joints.

15. Torchio, following experiments made by him, and just prior to his application for the patent in suit, recommended for adoption by New York Edison Company for high tension cables a form of cable joint which consisted of making the joint by insulating it in the usual way, and wrapping around its outside insulating jacket a copper gauze carefully held at the ends under the edges of the lead sheath, carefully pressed down, and by a lamp wick, the whole enclosed in a lead sleeve filled with a light oil, and at the same time stated that with cables not operating at such high potentials, it may still be desirable to adopt the same principle of filling the joint with a light oil and providing means for retaining the oil therein and preventing it from oozing out by having the light oil in the outer space replaced by a heavy oil.

16. While defendant was engaged in installing the electric cable joints alleged by plaintiff to be an infringement of the patent in suit, and on or about May 23, 1927, Metropolitan Device Corporation, at the time owner of said patent, informed defendant that a copper gauze stocking, the [fol. 870] patented feature, is what distinguishes the Metro-

latum Filled High Tension Cable Joint, referring thereby to the cable joint described in the patent in suit.

17. Defendant does not use, and has not at any time used, the copper gauze stocking, sheath or envelop, nor lamp wick; nor does defendant use the dense body of insulating material, or insulating compound of greater density, surrounding the joint wrapping impregnated with a lighter fluid.

18. Before making his alleged invention, Torchio knew of the use of a dome-shaped joint sleeve for providing a larger holding space or reservoir capacity for the oil in the sleeve, and in his preliminary studies had before him a drawing of a British joint box of that shape.

19. Prior to the time when Torchio made his invention, a British patent to Geipel, granted December 8, 1894, had disclosed the use of oil as the insulating material for filling the joint boxes or sleeves of paper or jute insulated electric conductors; de Gelder, in 1907, had disclosed the use of lead sleeves surrounding joints on high tension cables and the use of a joint insulating compound that was a rather thin resinous oil at 15 degrees Centigrade, or 59 degrees Fahrenheit, and a United States patent, granted February 26, 1895, to one Lemp, had disclosed the use of an oil reservoir to allow for expansion under increase of temperature in connection with the use of oil as an insulating medium in an electric transformer adapted to electric currents of high potential.

[fol. 871] 20. Prior to the time when Torchio made his alleged invention and in March, 1911, Charles Vernier, a British engineer, in a very detailed paper entitled "The laying and maintenance of transmission cables", read before the Institution of Electrical Engineers in England, and printed, published and distributed by said Institution, discussed and illustrated joints of high tension electric cables and the insulation of such joints. Vernier disclosed the use of lead sheathed high tension cables, and the construction and insulation of joints enclosed in hermetically sealed lead sleeves. He describes and illustrates a joint where the conductors are wrapped with pervious white linen tapes, boiled in resin oil, and he describes other types of joint not wrapped. Throughout his paper Vernier con-

demns the use of hard or solid joint compounds because of the tendency of voids, blow holes or air pockets to form in their mass. He specifically states that it is important that a joint insulated with pervious wrapping should be filled with an oil which will keep the insulating tapes constantly impregnated. For unwrapped joints he states that oil may be used but he prefers that a viscous compound of about the consistency of thick cream at ordinary temperatures, which never sets and in which cavities cannot form, be used. In some of the drawings annexed to his article, Vernier discloses enlarged or dome shaped joint sleeves to provide additional capacity for oil. In this publication Vernier condemns the use of hard or solid joint compounds and definitely teaches the use of oil in the sleeve of a joint having a pervious wrapping on the conductors, and of oil or a cream-like viscous compound in other joints.

[fol. 872] 21. The combination described in claim 4 of the patent in suit is substantially the same thing as is disclosed and described in the Vernier publication.

22. Prior to the time when Torchio made his alleged invention, it was known and had been disclosed in printed publications, that an electric cable heats when electrically loaded, and cools when the load is decreased, and that this causes expansion and contraction of the cable, the conductors and of the oil or other insulating compound in the cable and joint wrapping, being the expansion and contraction of the conductors due to changes of load, and results in squeezing oil out of the cable when expanding, and sucking it in again when contracting, known as the "breathing" of the cable; and it was recognized that by the use of oil in the cable joint the impregnation of the wrapping of the conductors was greatly assisted by the constant temperature changes which the cable undergoes under changes of load. The effect of the contraction and expansion of the cable was remarked in the Vernier article and discussions and was noted in the use of oil impregnated cable in Baltimore in 1911, at which time the practice was there adopted of avoiding the resulting overflow of the "pot-heads" or oil reservoirs by not filling the same to the top.

23. Prior to the time when Torchio made his alleged invention, it was known and had been disclosed in printed

publications, that when an electric cable is cut in order to make a joint, the impregnating oil of the cable end tends [fol. 873] to run out, known as "bleeding" of the cable, and it was recognized that this loss of oil could be restored by filling the joint sleeve with oil or other fluid compound.

24. Prior to the time when Torchio made his alleged invention, the use of domed joint or junction sleeves—enlarged at the top—to provide additional capacity for oil, was known and had been disclosed in printed publications, not only in the drawing of an English sleeve possessed by Torchio, but also in the Vernier article. An external oil reservoir was old for a like purpose in the Lemp transformer patent of 1895.

25. The record in the suit before the Circuit Court of Appeals in the Cleveland case contained none of the evidence presented on behalf of the defendant here, upon which findings numbered 11 to 24, inclusive, are based; nor did said record contain any equivalent or like evidence upon the basis of which like findings could there have been made.

26. The patent in suit does not contemplate the impregnation or reimpregnation of the wrappings in the cable outside of the joint sleeve with oil supplied to the joint, or the migration of the oil from the joint into the cable, but only for impregnating the wrappings at the joint and the insulation of the cable ends exposed in order to make the joint; with insulating oil. In 1925, the patentee, Torchio, applied for a patent which was issued to him January 12, 1932 (No. 1841-320), upon the alleged dis- [fol. 874] covery, as distinguished from the patent in suit, that by the use of a sufficiently light oil, one which flows more easily than the fluids generally used for impregnation of cables by manufacturers, and by taking advantage of gravity, or by the use of artificial pressure, the insulation can be maintained in good condition, not only at the joint, but also for considerable distances beyond the joint.

27. The form of the joint sleeve and receptacle or reservoir of the patent in suit, the same being hermetically sealed, rigid and of a constant capacity, would prevent any but a small amount of oil leaving the joint structure.

28. If and so far as oil contained in the joint sleeve of the patent in suit will migrate from the joint into the cable, oil or other fluid insulation in the joints disclosed by the Geipel patent and the de Gelder and Vernier publications, would likewise migrate into the cable.

29. The reservoir used by defendant as disclosed by the Peterson articles (Exs. 21 and 22), is in construction, character and use substantially different from that of the receptacle or reservoir of claim 4 of the patent in suit, in that defendant's reservoir is a weighted, collapsible, bellows type, variable volume, multiple connected reservoir, whereas the receptacle or reservoir of the patent in suit is rigid, part of the enclosing sleeve of the joint and incapable of use except with the joint of which it is a part. It is physically impossible to employ or use the receptacle or reservoir of the patent in suit as a substitute for de- [fol. 875] fendant's reservoir or as defendant's reservoir is employed and used.

30. The form of reservoir or receptacle disclosed by the patent in suit and mentioned in claim 4 thereof has never been used anywhere in or in connection with joints installed for actual use on a cable system.

31. The elements of the combination of claim 4 of the patent in suit were not only old, but produced no new results not contemplated by the prior art.

32. The patentee, Torchio, was not the original or first inventor or discoverer of any material and substantial part of the device or combination covered by claim 4 of the patent in suit.

Conclusions of Law

1. The filing of the disclaimer, February 11, 1927, in connection with the patent in suit, was not unduly delayed.

2. Claim 4 of the patent in suit is invalid in view of the prior art.

3. The bill of complaint should be dismissed with costs to the defendant.

New York, October 5, 1932.

Robert A. Inch, U. S. D. J.

[fol. 876] In United States District Court, Eastern District of New York

[Title omitted]

Plaintiff's Objections to Defendant's Proposed Findings of Fact and Conclusions of Law

Findings of Fact

8. This section should be erased. There is no support for it in the opinion.

10. This section should be erased. There is no support for it in the opinion.

11. This section in order to fairly correspond with the opinion should be amended by adding at the end, the following sentence quoted from page 3 of the opinion:

"Much thought and time had been spent in an effort to find some means which would prevent this trouble where extremely high voltage was necessarily used by concerns like defendant and must be safely distributed."

[fol. 877] 12. This section is not supported by the opinion except to the extent indicated by the following quotation, and should, therefore, be substituted by this quotation from page 7 of the opinion:

"It clearly appears that Torchio prior to his application for patent had gone abroad to see and study the progress of other companies in this matter of high tension cables."

13. This section is not supported by the opinion except to the extent indicated by the following quotation, and should be substituted by this quotation from page 7 of the opinion:

"Prior to Torchio's application for patent, Mr. Rabe who was at that time connected with the New York Edison Company had reported to Torchio as to high tension cable insulation at Boston, in this country."

14. In order to conform to the opinion, this section should be amended as indicated by the underscored words below:

"14. *There is testimony that indicates that* Torchio, in his work prior and leading up to, etc."

15. This section should be erased. There is no support for it in the opinion.

16. This section should be erased and substituted by the following in order to correspond to the opinion, page 4.

[fol. 878] "16. While the Metropolitan Company owned the patent, there is evidence, from correspondence between that Company and this defendant, that what was then considered the real invention was the 'gauze stocking' of Torchio, which he placed about the wrappings of the joint, and the dense body of insulating compound."

18. This section should be erased. There is no support for it in the opinion.

19. This section should be amended by striking out all reference to the deGelder patent. The opinion does not refer to it. This would be to erase the words commencing with "deGelder" in line 5 and ending with "Fahrenheit" in line 9.

20. This section should be erased for variance from the opinion, or should be brought into agreement with the opinion touching the Vernier articles as follows:

"Prior to the time when Torchio made his alleged invention, and in March 1911, Charles Vernier, a British Engineer, in a very detailed paper entitled 'The laying and maintenance of transmission cables', read before the Institution of Electrical Engineers, and constituting a printed publication duly distributed, discussed the joining of cables and the insulation of the joint. Vernier illustrated and described in his paper a very similar arrangement to Figs. 5 and 6 in the Torchio drawings, and stated that 'joints [fol. 879] of either type may be filled with an insulating oil or a joint box compound (of a solid or viscous nature)', but stated that some engineers object to oil because they feel that it would be absorbed, but went on to say that he had 'yet to meet a case where a breakdown has occurred from this cause.' He further stated that he 'considers it important that a joint insulated in the manner shown in Fig. 12 should be filled with an oil.' And if not 'oil' as

in the sample joint Fig. 13, then some 'viscous' compound of 'about the consistency of thick cream' at ordinary temperatures which, when heated will run as freely as heated oil. With this detailed paper before him, a competent electrical engineer would have before him sufficient guidance and suggestion on which to bring about the particular assembly now the subject of the claim in the Torchio patent."

22. This section should be erased. There is no support for it in the opinion.

23. This section should be erased. There is no support for it in the opinion.

24. This section should be erased. There is no support for it in the opinion.

25. This section should be erased. There is no support for it in the opinion.

26. The first sentence in this section should be erased as not in accordance with the opinion. The second sentence [fol. 880] should be substituted by the following in order to harmonize with the opinion.

"26. Later, in 1925, Torchio applied for and recently received another patent relating to the use of light oil. This is not necessarily material here."

27. This section should be erased. There is no support for it in the opinion.

28. This section should be erased. There is no support for it in the opinion.

29. This section should be erased. There is no support for it in the opinion.

30. This section should be erased. There is no support for it in the opinion.

32. This section should be erased. It is either repetitious or is much broader than any statement in the opinion.

Usina & Rauber, Solicitors for Plaintiff.

New York, N. Y., September 29, 1932.

DECISION OVERRULING OBJECTIONS

(Endorsed.)

Objections overruled. Exceptions granted in each instance.

Robert A. Inch.

Oct. 5, 1932.

[fol. 881] IN UNITED STATES DISTRICT COURT, EASTERN NEW YORK

In Equity. No. 5474

ELECTRIC CABLE JOINT COMPANY, Plaintiff,

against

BROOKLYN EDISON COMPANY, INC., Defendant

Present: Hon. Robert A. Inch, District Judge.

FINAL DECREE—Oct. 5, 1932

This cause came on to be heard at a term of this Court, on pleadings and proofs, and briefs having been filed by the respective parties, and the cause having been argued by counsel, thereupon, upon consideration thereof, findings of fact and conclusions of law having been made and entered of record, it was ordered, adjudged and decreed as follows, viz:

(1) That claim No. 4 of United States letters patent No. 1,172,322, issued February 22, 1916, to Philip Torchio, is invalid.

[fol. 882] (2) That the bill of complaint herein be and the same hereby is dismissed on the merits, and

(3) That defendant recover from plaintiff the costs of the defendant in this Court taxed at $317.60 and that defendant have judgment and execution therefor against plaintiff.

Robert A. Inch, U. S. D. J.

IN UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK

[Title omitted]

NOTICE OF APPEAL

SIRS: Please take notice that Plaintiff in the above entitled case appeals to the United States Circuit Court of Appeals for the Second Circuit from the decree of the Dis-
[fol. 883] trict Court of the United States for the Eastern District of New York, which was signed and entered on the 5th day of October, 1932, holding United States Letters Patent in suit No. 1,172,322, of February 22, 1916, invalid, particularly Claim 4 thereof. The grounds upon which this appeal is predicated are recited in the accompanying assignment of errors.

Yours, etc., Usina & Rauber, Solicitors for Plaintiff.

WXS:N.

Dated October 19, 1932.

To Messrs. Monroe & Byrne, No. 50 Broadway, New York City.

Copy of the above Notice of Appeal and attached Petition for Appeal and Assignment of Errors and order received this 19th day of October, 1932.

Monroe & Byrne, Solicitors for Defendant.

[fol. 884] IN UNITED STATES DISTRICT COURT

[Title omitted]

PETITION FOR APPEAL

SIRS: Electric Cable Joint Company, Plaintiff, in the above entitled suit, conceiving itself aggrieved by the decree made and entered herein on the 5th day of October, 1932, hereby appeals from said decree to the United States Circuit Court of Appeals for the Second Circuit and prays that this appeal may be allowed and a citation granted directed to the above named defendant, Brooklyn Edison Company, Inc., commanding it to appear before the Circuit

Court of Appeals for the Second Circuit; to do and receive what may pertain to justice to be done in the premises and that a transcript of record, proceedings and papers upon which the said decree was made, may be duly authenticated and sent to the United States Circuit Court of Appeals for the Second Circuit.

Electric Cable Joint Company by Usina & Rauber,
Solicitors for Plaintiff.

WXS:N.

Dated October 19, 1932.

[fol. 885] ALLOWANCE OF APPEAL

The foregoing Petition for Appeal is allowed this 24th day of October, 1932.

Robert A. Inch, U. S. D. J.

IN UNITED STATES DISTRICT COURT

[Title omitted]

ASSIGNMENT OF ERRORS

SIRS:—Plaintiff in the above entitled suit conceiving itself aggrieved by the decree made and entered herein on the 5th day of October, 1932, now appears, by its solicitors, and presents with its Petition for Appeal and Notice of Appeal from said decree, the following Assignment of Errors:

1. The Court erred in holding that United States Letters [fol. 886] Patent in suit No. 1,172,322, issued February 22, 1916, to Philip Torchio are invalid, and particularly Claim 4 thereof.

2. The Court erred in that it did not hold that United States Letters Patent in suit No. 1,172,322 are valid, and particularly Claim 4 thereof.

3. The Court erred in that it did not hold that defendant infringed United States Letters Patent No. 1,172,322, and particularly Claim 4 thereof.

4. The Court erred in that it did not award an injunction restraining and enjoining defendant from infringing United

States Letters Patent No. 1,172,322, and particularly Claim 4 thereof.

5. The Court erred in that it did not order an accounting of plaintiff's damages and defendant's profits, because of defendant's infringement of United States Letters Patent No. 1,172,322, and particularly Claim 4 thereof.

6. The Court erred in the following numbered findings of fact, namely 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32.

6a. The Court erred in failing to find, in connection with the matters of fact stated in finding of fact No. 11, that

"Much thought and time had been spent in an effort to [fols. 887–892] find some means which would prevent the difficulties arising at the joints of high voltage cables."

7. The Court erred in the following numbered conclusions of law, namely, 2 and 3.

Electric Cable Joint Company, by Usina & Rauber, Solicitors for Plaintiff.

Dated October 19, 1932.

Bond on appeal for $250.00 omitted in printing.

[fol. 893] Citation in usual form omitted in printing.

[fol. 894] In United States District Court

[Title omitted]

Præcipe for Transcript of Record

To the Clerk of the Court:

You are hereby respectfully requested to make a transcript of record in the above entitled suit, to be filed with the United States Circuit Court of Appeals for the Second Circuit, pursuant to the appeal heretofore allowed to Plaintiff-Appellant and to include in such transcript of record the following:

1. Bill of Complaint.
2. Answer of Defendant.

3. Minutes of Trial, in narrative and condensed form, including testimony of the following:

(a) Plaintiff's prima facie proofs—testimony of: Frank N. Waterman;

(b) Defendant's proofs—testimony of: Russell K. [fol. 895] Glover, George M. Lyons, Harry R. Woodrow, August R. Rabe, John B. Whitehead;

(c) Plaintiff's rebuttal testimony of: Albert B. Rypinski, Frank N. Waterman, recalled;

(d) Defendant's sur-rebuttal testimony of: Harry R. Woodrow, recalled.

4. Order approving narrative and condensed statement of minutes of trial.

5. Plaintiff's Exhibits:

1. U. S. Patent No. 1,172,322 of February 22, 1916, to Philip Torchio.

2. File wrapper and contents of U. S. Patent No. 1,172,322 to Philip Torchio.

3. Disclaimer in matter of U. S. Patent No. 1,172,322 of February 22, 1916, to Philip Torchio.

4. Excerpt from report of Committee on Underground Construction before Convention of the National Electric Light Association, New York, May 29 to June 2, 1911 (Exhibit No. 19 in Cleveland Suit).

5. Excerpt from Transactions of American Institute of Electrical Engineers, Volume XXXVI, January to December, 1917 (Exhibit No. 20 in Cleveland Suit).

6. U. S. Patent No. 277,335, May 8, 1883, to W. R. Patterson.

6A. U. S. Patent No. 416,143, November 26, 1889, to B. H. Wesslau.

[fol. 896] 6B. U. S. Patent No. 433,922, August 5, 1890, to G. L. Wiley and E. G. Acheson.

6C. U. S. Patent No. 488,027, December 13, 1892, to J. J. Purcell.

6D. U. S. Patent No. 706,599, August 12, 1902, to T. Rosati.

6E. U. S. Patent No. 888,674, May 26, 1908, to F. S. Viele.

6F. U. S. Patent No. 1,073,596, September 23, 1913, to H. C. Egerton.

7. U. S. Patent No. 165,535, July 13, 1875, to D. Brooks.

7A. British Patent No. 4824 of 1877, to Bristow Hunt.

7B. U. S. Patent No. 210,986, December 17, 1878, to D. Brooks.

7C. U. S. Patent No. 227,168, May 4, 1880, to W. W. Jacques.

7D. British Patent No. 11,932 of 1887 to Charles D. Abel.

7E. British Patent No. 16,237 of 1889, to S. Z. deFerranti.

7F. U. S. Patent No. 415,751, November 26, 1889, to B. H. Wesslau and G. Trautwein.

7G. U. S. Patent No. 1,083,170, December 30, 1913, to Doris Whipple.

7H. British Patent No. 29,756 of 1913, to J. F. Watson.

7I. British Patent No. 8,842 of 1914, to W. F. Price.

8. Opinion of Circuit Court of Appeals, Sixth Circuit, in Metropolitan Device Corporation versus Cleveland Electric Illuminating Company.

[fol. 897] 9. Certified copy of final decree in Metropolitan Device Corporation versus Cleveland Electric Illuminating Company.

10. Assignment from Metropolitan Device Corporation to Arthur J. Perfler.

11. Assignment from Arthur J. Perfler to Electric Cable Joint Company.

12. Assignment from Philip Torchio to Thomas E. Murray.

13. Assignment from Thomas E. Murray to Metropolitan Device Corporation.

14. Plaintiff's Interrogatories.

15. Defendant's Answers to Plaintiff's Interrogatories.

16. Drawing A "Cross-section of Cable in Duct".

17. Drawing B "Horizontal Section".

18. Drawing C "Vertical Section of Manhole".

19. Drawing D "Longitudinal Section".

21. Article by T. F. Peterson "Joints in High-Voltage Multiple-Conductor Cable".

22. Article by T. F. Peterson "Experience with Oil Reservoirs for Preventing Voids in High-Tension Cable".

23. Drawing E, Waterman's Drawing of "Defendant's Joint Construction".

24. Drawing F "Cables with Common Oil Reservoir".

25. Sketch by Waterman.

26. "Electrical World" of March 7, 1931.

27. Report to Torchio, February 13, 1915 (Exhibit No. 30 in Cleveland Suit).

[fol. 898] 28. Report to Torchio, February 15, 1915 (Exhibit No. 31 in Cleveland Suit).

29. Report to Torchio, February 24, 1915 (Exhibit No. 32 in Cleveland Suit).

30. Report to Torchio, February 18, 1915 (Exhibit No. 33 in Cleveland Suit).

31. Report to Torchio, March 1, 1915 (Exhibit No. 34 in Cleveland Suit).

32. Test Report on High Tension Splices November 27, 1914 (Exhibit No. 35 in Cleveland Suit).

33. Supplemental Test Report on High Tension Splices, November 30, 1914 (Exhibit No. 36 in Cleveland Suit).

34. Supplemental Test Report on High Tension Splices, December 2, 1914 (Exhibit No. 37 in Cleveland Suit).

35. Summary of Results of High Tension Splice Tests, December 14, 1914 (Exhibit No. 38 in Cleveland Suit).

36. Preliminary Analysis of High Tension Splice Tests, December 14, 1914 (Exhibit No. 39 in Cleveland Suit).

37. Summary of Results of High Tension Splice Tests, December 22, 1914 (Exhibit No. 40 in Cleveland Suit).

38. Summary of Results of High Tension Splice Tests, January 11, 1915 (Exhibit No. 41 in Cleveland Suit).

39. Summary of Tests on Splices Filled with Cable Oil Compounds (Exhibit No. 42 in Cleveland Suit).

40. Cross Section of Joint 20 (Exhibit No. 43 in Cleveland Suit).

41. Cross Section of Joint 23 (Exhibit No. 44 in Cleveland Suit).

[fol. 899] 42. Cross Section of Joint 24 (Exhibit No. 45 in Cleveland Suit).

43. Report to Rabe, February 13, 1915 (Exhibit No. 46 in Cleveland Suit).

44. Report to Rabe, February 19, 1915 (Exhibit No. 47 in Cleveland Suit).

45. Laboratory Test Sheet, February 2, 1915 (Exhibit No. 48 in Cleveland Suit).

46. Laboratory Test Sheet, February 11, 1915 (Exhibit No. 49 in Cleveland Suit).

47. Laboratory Test Sheet, February 2, 1915 (Exhibit No. 50 in Cleveland Suit).

48. Laboratory Test Sheet, February 8, 1915 (Exhibit No. 51 in Cleveland Suit).

49. Laboratory Test Sheet, February 12, 1915 (Exhibit No. 52 in Cleveland Suit).

50. Laboratory Test Sheet, February 16, 1915 (Exhibit No. 53 in Cleveland Suit).

51. Laboratory Test Sheet, February 16, 1915 (Exhibit No. 54 in Cleveland Suit).

52. Laboratory Test Sheet, February 13, 1915 (Exhibit No. 55 in Cleveland Suit).

53. Laboratory Test Sheet, February 5, 1915 (Exhibit No. 56 in Cleveland Suit).

54. Laboratory Test Sheet (Exhibit No. 57 in Cleveland Suit).

[fol. 900] 55. Laboratory Test Sheet, February 2, 1915 (Exhibit No. 58 in Cleveland Suit).

56. Laboratory Test Sheet, February 4, 1915 (Exhibit No. 59 in Cleveland Suit).

57. Laboratory Test Sheet, February 2, 1915 (Exhibit No. 60 in Cleveland Suit).

58. Laboratory Test Sheet, February 5, 1915 (Exhibit No. 61 in Cleveland Suit).

59. Laboratory Test Sheet, February 6, 1915 (Exhibit No. 62 in Cleveland Suit).

60. Letter, dated November 11, 1914, from Philip Torchio to A. Maxwell and others (Exhibit No. 63 in Cleveland Suit).

61. Order of January 30, 1915, for Stanoline (Exhibit No. 64 in Cleveland Suit).

62. Letter resending 16 quarts of Stanoline to Krass (Exhibit No. 65 in Cleveland Suit).

63. Letter, dated February 8, 1915, from R. W. Krass to Philip Torchio (Exhibit No. 66 in Cleveland Suit).

64. Drawing of "Dome Type" Cable Joint for Public Service Production Company of New Jersey.

65. Metropolitan Device Corporation Order from Public Service Production Company of August 24, 1926.

65A. Metropolitan Device Corporation Order from Public Service Production Company of August 24, 1926.

[fol. 901] 65B. Metropolitan Device Corporation Order from Public Service Production Company of September 14, 1926.

66. Blueprint of Complete Joint M. S.-55-D.

68. Certificate showing sealing of Watson British patent No. 29,756 of 1913.

69. British patent No. 15,413 of 1909 to Charles Vernier.

70. U. S. Patent No. 1,292,081 of January 21, 1919 to J. Sachs.

71. U. S. Patent No. 1,301,175 of April 22, 1919 to J. Sachs.

72. Sketch of Pot Head, shown in Handbook of Standard Underground Cable Company, Pittsburgh, Pa., 1906.

6. Defendant's Exhibits:

A. Handbook, Standard Underground Cable Company, Pittsburgh, Pa., 1906, page 42-A.

B. Letter to National Conduit & Cable Company ordering Compound—May 24, 1911.

C. Letter from National Conduit & Cable Company May 22, 1911.

D. Letter from National Conduit & Cable Company May 26, 1911.

E. Invoice (4 Sheets) June 1, 1911.

F. Letter to Mr. Torchio, July 7, 1914, from F. W. Smith.

G. Report of Mr. Torchio (Undated) marked "File 213-F".

H. Letter from Mr. Cole to Mr. Torchio—July 17, 1914. [fol. 902] I. Letter from Mr. Cole to Mr. Torchio—July 22, 1914.

J. Report of Mr. Rabe (Undated) "File-213-A".

K. Letter to Mr. Torchio from Mr. Clark—July 23, 1914.

L. Letter to Mr. Torchio from Mr. Cole—Sept. 12, 1914.

M. Letter to Mr. Clark from Mr. Torchio—Sept. 26, 1914.

N. Letter to Mr. Torchio from Mr. Whipple—Oct. 8, 1914.

O. Letter (Report) of Mr. Torchio (Not Signed) October 21, 1914.

P. Letter (Report) of Mr. Torchio (Not Signed) November 11, 1914.

Q. Letter (Report) of Mr. Torchio (Not Signed) February 2, 1915.

R. Letter from Mr. Torchio to Mr. Smith February 23, 1915.

S. Letter from Metropolitan Device Corporation to Mr. J. C. Parker May 23, 1927.

T. Sketch by Woodrow.

U. Photo No. 17,453 Weighted Reservoirs of Defendant's Installation.

V. Photo No. 17,466 of Testing Apparatus.

W. Records of Consolidated Gas Electric Light & Power Company, Baltimore, Md.

X. Telegraphic Journal and Electrical Review, March 4, 1887, pages 201-202 and 203.

Y. Standard Underground Cable Company, pages 43, 108 and 109.

[fol. 903] Z. Patents and Publications ("Defendant's New References"):

District of Columbia, Report of Electrical Commission, Ex. Doc. 15—1892.

Geipel, British Patent No. 11,280 of 189[illegible].

de Gelder, Translation of Dutch Article re: Cable System of Amsterdam, 1907.

Lemp, U. S. Patent No. 534,802 of 1895.

Vacuum Method of Filling Cable Joints (The Electrician 1911).

Vernier, British Patent No. 12,146 of 1909.

Vernier, "The Laying and Maintenance of Transmission Cables" (Journal of Institution of Electrical Engineers, Vol. 47, 1911).

Vernier, "The Laying and Maintenance of Transmission Cables" (The Electrician March 10, 1911).

AA. U. S. Letters Patent No. 1,841,320—Torchio.

BB. Photostat of Metropolitan Device Corporation Advertisement, Electrical World—April 16, 1927.

CC. Photostat of Metropolitan Device Corporation Advertisement, 1925.

DD. Drawing of "Dome Type" Joint (Woodrow).

The following plaintiff's exhibit is not to be included in the transcript of record, but definitely identified therein [fol. 904] and transmitted to the Court of Appeals as a physical exhibit:

Plaintiff's Exhibit No. 20—Piece of Cable.

7. Opinion of Judge Inch.

8. Findings of Fact and Conclusions of Law.

9. Plaintiff's Objections to Defendant's Proposed Findings of Fact and Conclusions of Law.

10. Final Decree.

11. Notice of Appeal.
12. Petition for Appeal and Order allowing same.
13. Assignment of Errors.
14. Bond.
15. Citation.
16. This Præcipe.
17. Order as to correctness of record.
18. Clerk's Certificate.

Electric Cable Joint Company, by Usina & Rauber, Solicitors for Plaintiff. Brooklyn Edison Company, Inc., by Monroe & Byrne, Solicitors for Defendant.

It is so ordered.

Robert A. Inch, United States District Judge.

Dated November 22, 1932.

[fol. 905] In United States District Court

[Title omitted]

Stipulation as to Transcript of Record

It is hereby stipulated and agreed, that the foregoing (in 2 vols.) is a true copy of the transcript of the record of the said District Court in the above-entitled matter as agreed on by the parties.

Usina & Rauber, Attorneys for Plaintiff. Monroe & Byrne, Attorneys for Defendant.

Dated February —, 1933.

On reading the foregoing consent of the attorneys for the respective parties herein, it is

Ordered that the foregoing printed record be filed in lieu of the original papers for the purpose of certifying a record on appeal.

—— ——, United States District Judge.

Dated February —, 1933.

[fol. 906] Clerk's certificate to foregoing transcript omitted in printing.

UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SECOND CIRCUIT, OCTOBER TERM, 1932

No. 393

Argued May 10, 1933. Decided September 21, 1933

ELECTRIC CABLE JOINT COMPANY, Complainant-Appellant,

v.

BROOKLYN EDISON COMPANY, INC., Defendant-Appellee

Appeal from the District Court of the United States for the Eastern District of New York

Before Manton, Swan, and Augustus N. Hand, Circuit Judges

From a decree dimissing the complaint in a suit for infringement by the defendant of claim 4 of United States patent No. 1,172,322 because of invalidity in view of the prior art, the complainant appeals. Affirmed.

Usina & Rauber, of Washington, D. C. (Anthony Usina and Melville Church, both of Washington, D. C., of counsel), for complainant-appellant.

Monroe & Byrne, of New York City (Charles Neave and John D. Monroe, both of New York City of counsel), for defendant-appellee.

AUGUSTUS N. HAND, Circuit Judge:

This is the ordinary suit for patent infringement. The patent is No. 1,172,322 to Philip Torchio, and the only claim in issue is claim 4, which reads as follows: "An electric cable, comprising a sheath, a line conductor having a joint, a body of pervious insulating material inclosing said joint, the said sheath being removed for a distance sufficient to expose said pervious body, a sleeve of impervious material of greater diameter than said body, inclosing the same and hermetically united at its ends to said cable sheath, a receptacle communicating with the interior of said sleeve, and an insulating fluid adapted to permeate said pervious body contained in said receptacle and the space between said body and said sleeve."

According to the specification, the invention is a device for preventing current leakage at a joint in an electric line conductor. It consists in a construction "whereby the joint is immersed in a fluid insulating medium adapted to permeate the pervious wrapping of the joint, whereby said fluid after permeation of said wrapping is retained therein by a denser body of insulating material surrounding said wrapping, and whereby the joint is inclosed in two metallic sleeves united at their ends to one another, separated between said ends and electrically connected at said ends to the cable sheath, whereby the potential on the said sleeves becomes that of the sheath and breaking down of insulation between said sleeve or ionization of air between them is prevented."

The patentee, after stating that a fluid insulating compound adapted to permeate the interstices in the insulating wrappings and filling of the joint is poured through two holes in the sleeve, goes on to say that he found that the fluid compound did not operate efficiently. To explain this lack of efficient operation, he says that, in case of some of the fluid compounds, voids or openings were formed, due to the contraction of the material on cooling and hardening. In others, because of their quick cooling and hardening, due to contact with the cold insulation, the fluid fails to permeate the wrappings and filling. He says that in almost all of them the insulating liquid if rendered fluid by heat causes a deterioration of the insulation at the point where the liquid first meets the insulation; that in all of them, the insulating compound on hardening will crack under mechanical stresses, especially when the conductors carry heavy overload currents. He remarks that: "The consequence is that, by reason of these cracks and voids and the ionization of air in them, a lowering of dielectric strength of the joint insulation takes place, so that electric lines transmitting high tension currents, especially if underground, have their weakest places at the joints and at the ends of the sheathing * * * where connected to the joint covering sleeve * * *."

The patentee says that he has succeeded in overcoming the foregoing difficulty by filling "the sleeve and reservoir with any suitable insulating oil or other liquid which is fluid at low temperature and preferably of a character which will combine with the material used in the body of the cable for permeating or embedding the insulating wrappings." He

says that he preferably forces liquid into the sleeve under pressure sufficient to drive it into the interstices of the cable ends and into the joint wrappings and fillings; and that when the introduction of the liquid is complete he permits it to fill the reservoir which is finally closed. He adds that: "The oil in the reservoir then serves to supply any deficiency in the sleeve caused by absorption and breathing of the cable or the disturbance of the conductors carrying sudden overload currents, so that the joint insulation is not only thoroughly permeated at the outset, but continues submerged in a bath of insulating oil." He says that instead of making the reservoir in the form of a separate chamber communicating with the sleeve, one may dispose the sleeve eccentrically on the joint, so that the greatest clearance will be uppermost, and that in this way one may produce an additional holding space for the oil within the sleeve itself. He also remarks that where for any reason it is not desirable to keep the sleeve filled with a light fluid, such as oil, one may first cause the wrappings and filling of the joint to be permeated with a light fluid and then afterward draw off the surplus liquid and substitute therefor an insulating compound of greater density to fill the space between the joint and the sleeve. The dense compound then acts both as an insulator and as a means of imprisoning the lighter fluid already in the interstices of the filling and wrappings of the joint. He says finally that: "The insulating fluid not only permeates the wrappings and fillings at the joint, but also percolates into the insulation of the cable ends exposed in order to make the joint. This is of practical importance, because it often happens that during the making of the joint, the exposure of said ends permits of the permeating liquid used in the original manufacture of the cable to 'bleed' or run out, and a consequent failure of insulation at these points ensues. This I have found to be the cause of breakdowns which were apparently unaccountable. The new fluid put into the joint sleeve supplies this loss and effectually prevents the difficulty."

The protective device for electric cable joints was limited in a disclaimer filed by Thomas E. Murray, the assignee of Philip Torchio, whereby Murray made "disclaimer of the improvement described except for electric cables which comprise a line conductor, insulating wrapping permeated with insulating compound and a sheath of flexible inelastic

metal constituting a unitary product of manufacture and commerce which is portable and capable of being drawn through conduits; and, except as to an insulating liquid which is fluid at ordinary working temperatures of such cables and in quantity sufficient to supply at all times the demands made by the cable in use, and by the joint."

Claims 3 and 4 of the patent in suit were before the Circuit Court of Appeals of the Sixth Circuit in Metropolitan Device Corp. v. Cleveland E. Illuminating Co., 36 F. (2d) 477, 479. That court upon the record before it, which was a very different one from that before this court, sustained the patent and held it infringed. Judge Hicks who wrote the opinion stated the basis for the decision as follows: "In * * * cables carrying in excess of 15,000 volts, the dielectric loss from faulty insulation, with the resultant destruction of the wrappings of the cable and the breaking down of the joints, was serious. Torchio discovered that this loss was due in part to the 'bleeding' of the insulating compound from the exposed cable ends during installation. He also discovered that the cable 'breathed' or 'sucked', that is, that while in use the heat expanded it and that it correspondingly contracted while cooling; that this bleeding and expansion of the cable forced the insulating compound from the interstices of the pervious insulating wrappings and fillings, permitting dielectric loss and structural damage. The problem was to restore this lost insulation. The teaching had been that the insulating compound in the joint should not be soft enough to flow. The thought was that the compound should not be permitted to escape and leave the joint unprotected. Torchio substituted a liquid insulating compound for the compound with a low melting point theretofore in use in the cable sleeve. Torchio's liquid compound would and did, especially under pressure, flow along the cable length between the conductors and the leaden sheath and refill the empty cells of the pervious insulation. This was new and useful and was a commercial success. It was not a mere refinement of the former method; it was a reversal of it. We think it was somewhat beyond the skill of an expert and amounted to patentable invention."

The only difference between claim 3 and claim 4 of the patent is that the latter contains the additional element of "a receptacle communicating with the interior of * * *

(the) sleeve" for the purpose of furnishing a supply of oil external to what is contained in the space between the "pervious body" and the "sleeve." The Court of Appeals for the Sixth Circuit did not discuss any difference between claims 3 and 4 and the former was withdrawn from consideration in the present suit.

The prior art before the Court of Appeals for the Sixth Circuit was much less impressive than that here. As new prior art we have first of all the British patent to Geipel No. 11,280 (A. D. 1894). The invention there related to improved methods of joining electric conductors whereby the insulation of the joint is more easily effected. The patentee says that after the joint is made the box "may be filled with a suitable insulating material, as for example, oil, wax, bitumen, or by a combination of any of these according to the nature of the insulation used for the conductor itself. * * * With paper or jute insulated conductors oil may be used."

In the United States patent to Lemp No. 534,802 the invention related to transformers or converters and was designed especially to provide a construction adapted to furnish the heavy currents employed in electric welding and other metal working apparatus. A reservoir is shown to contain a supply of oil. The patentee says when "the secondary has been placed around the primary and the proper liquid tight joints formed, as described, it is filled with oil, connection with a reservoir or supply pipe being maintained to allow for expansion under increase of temperature." Claim 11 of this patent is as follows: "11. The combination, substantially as described, in a transformer, of a tubular secondary inclosing the primary and filled with oil, and an oil reservoir or standpipe connected with said tubular secondary, as and for the purpose described."

In 1907, De Gelder, in a thesis written to obtain a degree in science at the Academy of Delft, described the Cable System of the Municipality of Amsterdam. While he was apparently dealing with cables having a relatively low tension, he says: "The impregnation of the paper insulation should take place with a rather thin liquid, oily and a not too resinous mass. It may be true that a dry, resinous mass gives a higher insulation resistance when measured, but it is much less resistive against breakdown."

After setting forth the process of making the joint, he describes the immersion of the joint in the insulating fluid as follows: "After the soldering of the lead socket has been completed, a small square hole is cut in the top of the lead socket, and hot insulation mass is poured into the socket. For this purpose, the same mass, or rather the same oil, is used as for impregnating the cable. It is a kind of resin oil. After the socket has been filled, the hole is closed again by soldering."

De Gelder remarks in his thesis that German cables have a thicker mass of impregnating oil than do the British cables in which "a rather thin resinous oil is used at 15° C." He says that a thinner mass gives a better guaranty against breakdown than a harder one, and adds that: "The flowing of the mass from the junction boxes, caused by too intense heating, is more dangerous. In fact, if the mass is pressed out because of too strong heating, it is highly probable that, when contraction takes place, water will be sucked in, even though the junction box may be well sealed, * * * However, according to our observations the mass will not flow from correctly assembled junction boxes, such as those used by the Municipal Electric Works, until the temperature of the cable has become 90° C., which temperature doubtlessly will not be permitted to occur, for other reasons."

It is apparent from the foregoing that De Gelder understood that cables "breathe" under changes of temperature due to the passage of more or less current in the conductors and that the use of a thin oil is advantageous.

The use of a thin oil in the potheads of the Consolidated Gas Company of Baltimore in order to prevent the drying out of the ends of the cables illustrated the advantages of a thin liquid as compared with the paraffin which had formerly been used. This oil caused an impregnation of the wrappings of the cables for a considerable distance beyond the ends and demonstrated that there was a "breathing" process going on when the cables became hot, because the potheads then overflowed. This substitution of oil for paraffin in 1911, because it was found to be more advantageous, is authenticated by documentary evidence and the oil was used in connection with 13,000 volt cables. The supply of oil for replenishing the potheads was kept in barrels and drawn out through a spigot and under ordi-

nary conditions of temperature had the consistency of molasses. It penetrated a long distance into the joint sleeves and dissolved the paraffin originally used as an insulator. The use of this oil demonstrated practically everything peculiar to Torchio's invention.

The Vernier article published in the Journal of the Institution of Electrical Engineers in 1911 on "The Laying and Maintenance of Transmission Cables" was produced at the trial of the present suit but was not before the Court of Appeals of the Sixth Circuit.

Vernier discusses the joining of Extra High Tension Cables and remarks that badly designed joints will prove a constant source of trouble. He warns against the presence of air with which he says "ionization no doubt takes place" and recommends boiling the insulating tapes to be used on the cables in oil and also saturating them with oil before wrapping so as to fill all crevices between layers and thus to exclude air pockets. He says: "Joints * * * may be filled either with an insulating oil or a joint box compound (of a solid or viscous nature). Oil is objected to by many engineers, who fear its being absorbed up the cores of the cables, and who therefore insist on a joint-box compound being used. Although one hears this absorption of the oil frequently mentioned, the author has yet to meet a case where a breakdown has occurred from this cause, and with cables impregnated under vacuum, as E. H. T. Cables always are, the leakage should in any case be very small." He adds that: "The author considers it important that a joint insulated in the manner shown * * * should be filled with oil." (Record, p. 774). And says (at page 774) that the cores should be separated at intervals by bands of insulating tape "so as to allow the greatest possible freedom of access to the oil, which will keep the insulating tapes constantly impregnated, and this will be greatly assisted by the constant temperature changes which the cable undergoes under changes of load." These remarks show that Vernier understood the so-called breathing of the cables and realized that it would assist in forcing oil into the tapes and in filling any voids that have arisen. It is plain that Torchio did not discover the tidal action of the cable whereby as the temperature rises the oil is drawn out, and as the temperature falls it is sucked in again. Vernier not only understood it and set it forth in his ar-

ticle, but showed that it was of use in reimpregnating cables.

Vernier also realized that air would get into the cores and insulation of the cable when when it was cut and the oil ran out and that this air pocket would cause a breaking of the joints due to sparking across the air space. This is the "bleeding" which Torchio is said to show how to repair. Vernier says that "an oil filling should in such cases be used" (Record, p. 775).

Vernier described the use of oil for the the same purpose as did Torchio. It is perhaps true that he particularly recommended a joint box compound that is "viscous and of about the consistency of thick cream at ordinary temperatures," which "when heated * * * should run as freely as heated oil, so as to penetrate all crevices, and * * * must retain these features throughout its life." Such a compound, however, would not differ from that which the Court of Appeals of the Sixth Circuit held to infringe, for it would be an insulating liquid fluid at ordinary working tempertures of the cables and would meet the claims of the Torchio patent. But irrespective, however, of the character of such a compound, Vernier described with considerable detail the use of an oil as distinguished from it, for the benefit of those who might desire to use the oil.

We can find nothing in claim 4 that is not fully disclosed in Vernier's article, but the separate "receptacle" for an additional supply of oil Such a receptacle if it could be regarded as an element, which would create a patentable invention, was foreshadowed in the patent to Lemp. But the addition of this element does not render a claim otherwise invalid patentable. Westinghouse Elec. & Mfg. Co. v. Pittsburgh Transformer Co. (D. C.) 10 F. (2d) 593; at page 596; R. Herschel Mfg. Co. v. Great States Corporation (C. C. A.) 26 F. (2d) 362. Only distinctions that have no patentable merit can differentiate Torchio's claims from what has gone before.

The letter of Torchio to Smith of February 23, 1915, was only written fourteen days before Torchio filed his application for the patent in suit. It contained the following:

"Two weeks ago"—which would mean about February 9—"I mentioned to you and Mr. McCoy the hopes I entertained of having reached the solution by a form of joint

which consists of making the splice by insulating it in the usual way, but wrapping around its outside insulating jacket a copper gauze, which is carefully held at the ends under the edges of the lead sheath, carefully pressed down, and by a lamp wick; the splice so made is then enclosed in a special sleeve, which is then filled under vacuum with a very light oil which penetrates and fills not only the insulation and voids in the splice, but also the disturbed ends of the cable. * * *

"With cables not operating at such high potentials as the New Haven service requires, it may still be desirable to adopt the same principle of filling the splice with a light oil and providing means for retaining the oil therein and preventing it from oozing out if perchance the annular space around the insulation in the splice is drained off, and does not retain in full, the light oil. For this purpose I have also tested two splices made without the metal armor and wick, but having the light oil in the outer space replaced by a heavy oil."

It is evident from the foregoing that Torchio was in much the same position as Vernier. Each was familiar with the use of a light oil and knew its advantages and some of its real or supposed disadvantages. Torchio, among other things, had in mind the use of "an insulating compound of greater density than said liquid to fill the space between the joint and the sleeve." This he mentions in his patent. He also had in mind a wire gauze envelope which would prevent the breakdown of the insulation between it and the lead sleeve even if cracks or voids happened to be formed in the insulation. These appear to have been novel features of Torchio's device which he described in the letter of February 23, 1914, and embodied in some of his claims. They do not appear in claim 4, all the elements of which were part of the prior art, both separately and in combination, with the exception of the receptable for surplus fluid, which was not only shown in other devices but was an obvious addition if a supply of oil greater than the sleeve would hold were desired.

So long as Vernier or Torchio employed a liquid which was fluid at ordinary working temperature and would flow into the cable when the wrappings became dry or the oil was sucked out by the breathing process, the desired result was effected. Each seems to have had the same thing in mind. Torchio was seeking to avoid the old fluid com-

pounds which hardened and cracked when they cooled and consequently let in air and failed to permeate the wrapping and filling. He provided no particular quality of oil, but like Vernier one of such fluidity that by the breathing of the cable it would be drawn in and out of the joint.

The District Court held the patent invalid in view of the prior art and dismissed the bill. With this we agree.

Decree affirmed.

Manton, Circuit Judge, dissents with opinion.

UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SECOND CIRCUIT, OCTOBER TERM, 1932

No. 393

Argued May 10, 1933. Decided September 21, 1933

ELECTRIC CABLE JOINT COMPANY, Complainant-Appellant,

v.

BROOKLYN EDISON COMPANY, INC., Defendant-Appellee

Appeal from the District Court of the United States for the Eastern District of New York

Before Manton, Swan, and Augustus N. Hand, Circuit Judges

MANTON, Circuit Judge (dissenting):

With the statement of claims of the patentee as set forth in the prevailing opinion I agree. The patent in suit has features of novelty. The immersion of the joint in an insulating medium, fluid at ordinary working temperatures and adapted to permeate the pervious wrapping, and the provision for the reservoir of fluid in addition to that carried in the joint sleeve constituted novelty. The oil within the joint sleeve flows or migrates in time into the cable, sometimes for great distances beyond the joint, and the deficiency of the oil is made up in the joint by oil flowing out of the reservoir. This is covered by claim 4, the one claim in suit. It is the flowing of the oil which continuously takes place throughout the cable which eliminates the dan-

gerous voids, and the inventor overcame losses of electrical current by this invention, avoiding breakdowns of the joints or of the cables.

An examination of the prior art convinces me that he was the first to discover the so-called breathing of the cable which would soak in the oil thus filling the crevices or voids. The Circuit Court of Appeals for the Sixth Circuit [Metropolitan Device Corp. v. Cleveland Electric Illuminating Co., 36 F. (2d) 477] sustained this patent.

The prior art, referred to in the prevailing opinion, does not disclose this invention. The problem was to restore the lost insulation. Prior to the patent in suit, the teaching had been that the insulating compound in the joint should not be soft enough to flow. The thought was that the compound should not be permitted to escape and leave the joint unprotected. The patentee substituted a liquid insulating compond for the compond with a low melting point theretofore in use with the cable sleeve. The liquid compound would and did, especially under pressure, flow on the cable length.

The insulating schemes referred to by the Vernier patents, dealing in prophecy, have no description of an actual joint in service. Vernier does refer to insulating oil, solid compound, and viscous compound. He says that there should be very little leakage of oil up the cores and that such leakage could be absolutely prevented. He did not have the conception of the migration of oil caused by the breathing of the cable and his remedy was to prevent leakage and not to provide oil in quantities sufficient to compensate for it. His recommendation was for viscous compound and the important thing about this was its opposition to mobility. In his patents, the outer joint box did not have a reservoir, while the patent in suit does, and has a sufficient quantity of oil to supply, at all times, the demands made by the cable and joint by the breathing operation.

The Geipel patent did not provide for pervious wrapping of the cable ends in the joint box. The oil does not fill the joint casing and the cable ends project above the surface of the body of oil.

The De Gelder paper describes joints working on the reverse principle of the joints referred to in the patent in suit. The joints spoken of are not used in high-tension cables and the paper speaks of an impregnated mass not too soft

or too thinly liquid. It refers to the flowing of the mass from the junction boxes caused by too intense heating as "more dangerous"; it also refers to resinous oil and a thicker mass. This is contrary to the thought of the patent in suit, which was to have the liquid soaking or flowing.

The letter of the patentee refers to his wide experimentation and difficulty he experienced in overcoming the idea of using compounds other than liquid oil. He shows that he had been adverse to the use of oil at first, but was converted to its use just before filing his patent application. Infringement is clearly established.

The judgment should be reversed.

UNITED STATES CIRCUIT COURT OF APPEALS, SECOND CIRCUIT

At a stated term of the United States Circuit Court of Appeals in and for the Second Circuit, held at the court-rooms, in the Post Office building, in the city of New York, on the 28th day of September, one thousand nine hundred and thirty-three.

Present: Hon. Martin T. Manton, Hon. Thomas W. Swan, Hon. Augustus N. Hand, Circuit Judges.

ELECTRIC CABLE JOINT COMPANY, Plaintiff-Appellant,

vs.

BROOKLYN EDISON COMPANY, INC., Defendant-Appellee

Appeal from the District Court of the United States for the Eastern District of New York

This cause came on to be heard on the transcript of record from the District Court of the United States for the Eastern District of New York and was argued by counsel.

On consideration whereof, it is now hereby ordered, adjudged, and decreed that the decree of said District Court be, and it hereby is, affirmed, with costs.

It is further ordered that a Mandate issue to the said District Court in accordance with this decree.

Wm. Parkin, Clerk.

[Endorsed:] United States Circuit Court of Appeals, Second Circuit. Electric Cable Joint Company vs. Brook-

lyn Edison Company, Inc. Order for Mandate. United States Circuit Court of Appeals, Second Circuit. Filed Sep. 28, 1933. William Parkin, Clerk.

UNITED STATES OF AMERICA,
Southern District of New York:

I, William Parkin, Clerk of the United States Circuit Court of Appeals for the Second Circuit, do hereby certify that the foregoing pages, numbered from 1 to 915, inclusive, in 2 volumes, contain a true and complete transcript of the record and proceedings had in said Court in the case of Electric Cable Joint Company, Plaintiff-Appellant, against Brooklyn Edison Company, Inc., Defendant-Appellee, as the same remain of record and on file in my office.

In testimony whereof I have caused the seal of the said Court to be hereunto affixed, at the City of New York, in the Southern District of New York, in the Second Circuit, this 31st day of October, in the year of our Lord one thousand nine hundred and thirty three, and of the Independence of the United States the one hundred and fifty eighth.

Wm. Parkin, Clerk. (Seal United States Circuit Court of Appeals, Second Circuit.)

(4259)

[fol. 920] SUPREME COURT OF THE UNITED STATES

ORDER ALLOWING CERTIORARI—Filed January 8, 1934

The petition herein for a writ of certiorari to the United States Circuit Court of Appeals for the Second Circuit is granted. And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.

Endorsed on cover: File No. 38,214. U. S. Circuit Court of Appeals, Second Circuit. Term No. 611. Electric Cable Joint Company, petitioner, vs. Brooklyn Edison Company, Inc. Petition for a writ of certiorari and exhibit thereto. Filed November 28, 1933. File No. 611, O. T., 1933.